

National Aeronautics and Space Administration



# Single-Event Transient Testing of the Crane Aerospace & Electronics SMHF2812D Dual DC-DC Converter

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Date



## 1. Purpose

The purpose of this testing was to characterize the Crane Aerospace & Electronics (Crane) Interpoint SMHF2812D for single-event transient (SET) susceptibility. These data shall be used for flight lot evaluation, as well as qualification by similarity of the SMHF family of converters, all of which use the same active components.

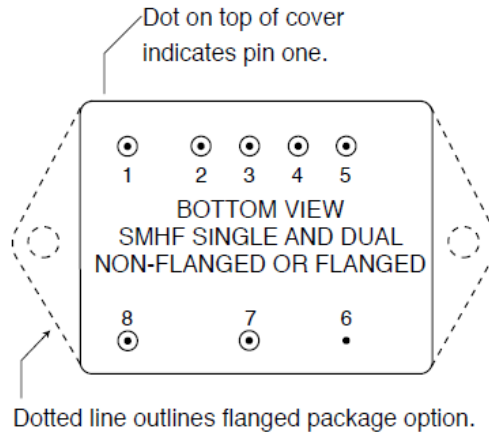
## 2. Test Samples

The Interpoint SMHF Series of 28 V DC-DC converters offers a wide input voltage range of 16 to 45 V and up to 15 W of output power. The SMHF converters are switching regulators that use a quasi-square wave, single-ended forward converter design with a constant switching frequency of 550 kHz. Isolation between input and output circuits is provided with a transformer in the forward path and a temperature compensated opto-coupler in the feedback control loop. The “R” at the end of the flight part number indicates that these parts have a guaranteed total ionizing dose hardness of 100 krad(Si).

Six (6) parts from two flight lots were provided to NASA/GSFC Code 561 Radiation Effects and Analysis Group for SET testing. There was a design change between the two lot date codes and the project will be flying both versions; hence, both were tested. All six parts were prepared for testing by mechanically delidding each device. They were then soldered to mechanically-milled copper clad test boards that were designed specifically for this testing. Since the number of overlayers and materials vary throughout this hybrid device, linear energy transfer calculations are determined based on the top-surface incident ion species and kinetic energy. More information can be found in Table 1.

**Table 1: Part Identification Information**

Flight Part Number	SMHF2812DF/KR
Generic Part Number	SMHF2812D
Manufacturer	Crane Aerospace & Electronics
Lot Date Codes and Quantities	1021 (4) and 1214 (2)
Package Type	GDFP1-G16
REAG ID #	14-021



**Figure 1: Pin out for SMHF2812D 28 V DC-DC Converter.**

**Table 2: List of Pin Numbers and Their Functions**

Number	Function
1	Inhibit (No Connect)
2	Positive Output
3	Output Common
4	Negative Output
5	Sync (Connected to Input Common)
6	Case Ground
7	Input Common
8	Positive Input

### 3. Test Facility

**Facility:** Texas A&M University Radiation Effects Facility. Tunes: 15 MeV/amu

**Flux:** Approximately  $3 \times 10^4$  ions  $\text{cm}^{-2} \text{s}^{-1}$

**Fluence:** All tests run to a fluence of  $1 \times 10^6 \text{ cm}^{-2}$

Table 3 shows the ion used during irradiation. Note that energy, range, and LET values are calculated based on 1 mil aramica window and 50 mm of air prior to the target. All irradiations were performed at normal incidence.

**Table 3: Ion Used during Irradiation**

Ion	Beam Energy (MeV/amu)	Energy (MeV)	Range in Si ( $\mu\text{m}$ )	Nominal LET in Si ( $\text{MeV-cm}^2/\text{mg}$ )
$^{109}\text{Ag}$	15	1170	107.2	43.6

## 4. Test Conditions and Error Modes

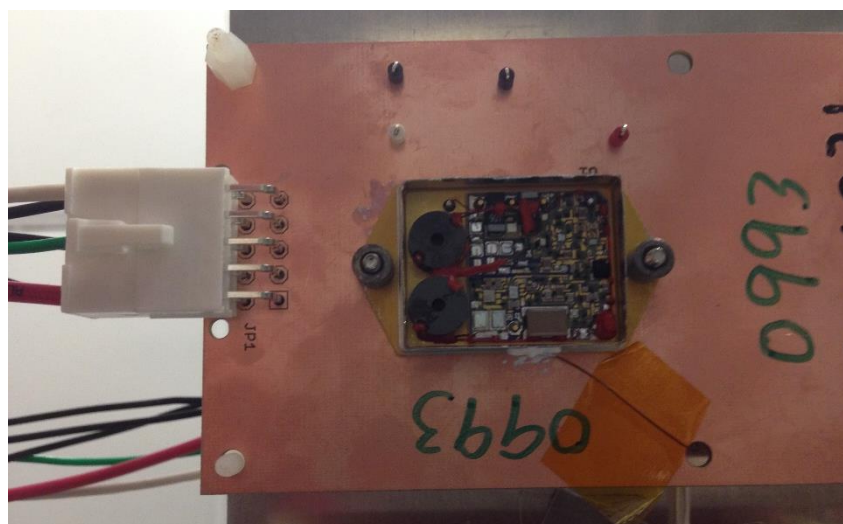
The conditions tested during irradiation are shown in Table 4. For all conditions tested, transients with amplitudes greater than  $\pm 1$  V were captured. The converters were nominally irradiated at room temperature, but the case temperature was monitored and recorded during each run. The oscilloscope was set to AC coupling to preserve transient voltage resolution; as a result, when plotted, the transients appear to be centered on 0 V, rather than the 12 V output voltage.

**Table 4: Test Conditions during Irradiation**

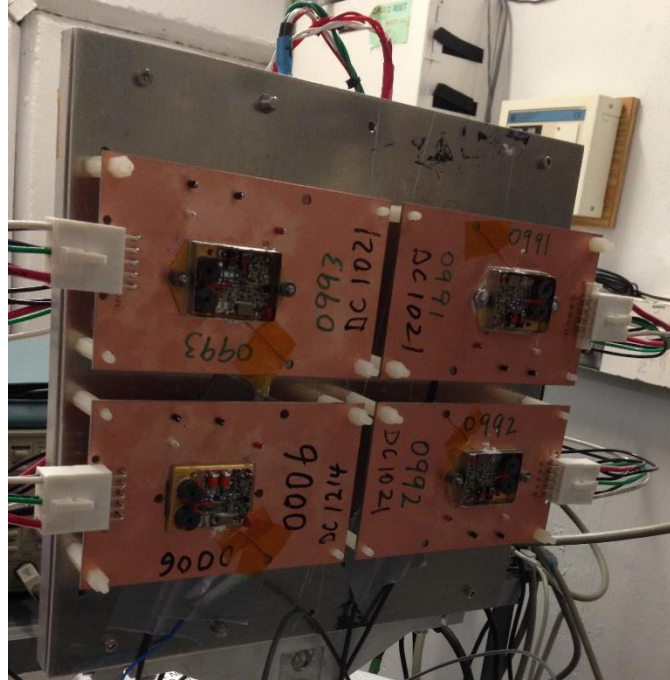
<b>Test Temperature</b>	Room Temperature
<b>Number of Locations Irradiated</b>	2 (Shown in Figure 2)
<b>Input Bias</b>	28 V, 35 V
<b>Load Conditions (<math>I_{load+}/I_{load-}</math>)</b>	90 mA/60 mA, 188 mA/188 mA

## 5. Irradiation Locations

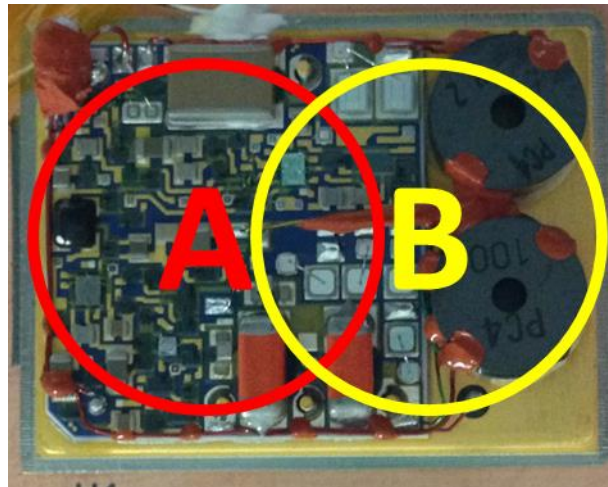
Figure 2 shows one of the converters with the lid removed and mounted on a daughtercard. Figure 3 shows four converters on the motherboard. Each converter is individually selected and moved in front of the beam. Figure 4 is a zoomed version of a single part with the irradiation locations indicated. The circles are roughly representative of the beam spot size and they are labeled location “A” and “B” to correspond with the beam run log, which can be found in Section 8. It should be noted that due to the mirror image layout of the motherboard, locations A and B will be on opposite sides of mirror image parts. The functional equivalents of each location are noted in the run log. Sections 9 and 10 show the motherboard and daughtercard schematics, respectively. Section 11 contains the strip tape of the supply current for each irradiation as described in the beam run log, as well as the corresponding case temperature.



**Figure 2: A Single Delidded SMHF2812D 28 V DC-DC Converter Mounted on a Daughtercard.**



**Figure 3: Four Delidded SMHF2812D 28 V DC-DC Converters Mounted on Daughtercards and Connected to the Motherboard.**

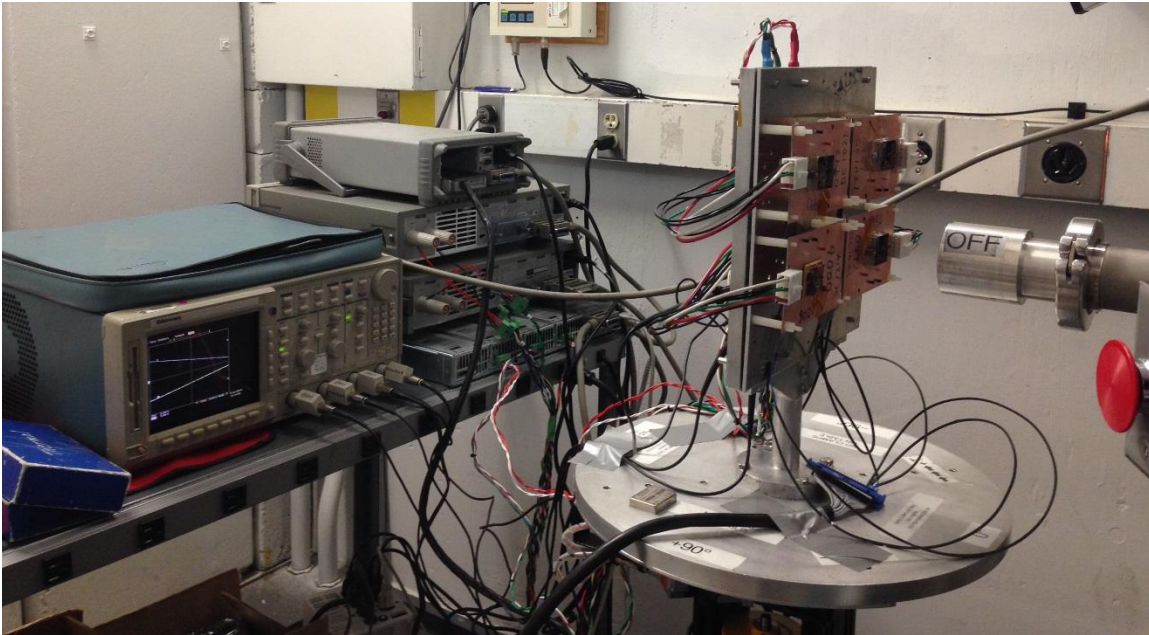


**Figure 4: A Single Delidded SMHF2812D 28 V DC-DC Converter with Sample Irradiation Locations Indicated.**

The test setup required a DC power supply for the input voltage, an electronic load, an oscilloscope for capturing the transients on the output, an data acquisition/switch unit for selecting the DUT, and two laptops equipped with LabView. Custom LabView code was written by Hak Kim, ASRC, for this testing. One program captured and saved the transients as they appeared on the oscilloscope. The other selected the DUT to be irradiated, set the input voltage, set the load conditions, and monitored the case voltage of the DUT. Table 4 lists the equipment used during these tests. Figure 5 shows the test set-up at the facility with the parts in the beam line and all the equipment behind.

**Table 4: List of Equipment Used**

Equipment	Serial Number	ECN
Agilent N6702A Four-Channel Power Supply	SG45000187	M161852
Tektronix TDS784C Digital Oscilloscope	B021226	1953620
Hewlett Packard 606B System DC Electronic Load	MY41002922	M16285
Dell Precision Laptop (Operated by A. Topper)	-----	237543
Dell Precision Laptop (REAG Extra)	-----	2332207



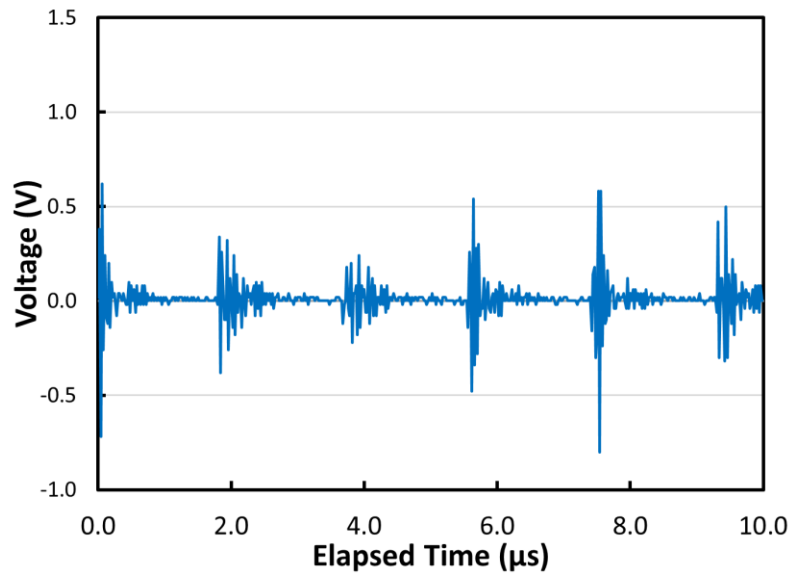
**Figure 5: Complete SMHF2812D 28 V DC-DC Converter Test Set Up. The Equipment Used Is Shown behind the Motherboard, which Is Populated with Four Converters Mounted on Daughtercards and Positioned in Front of the End of the Beam Line.**

## 6. Test Results

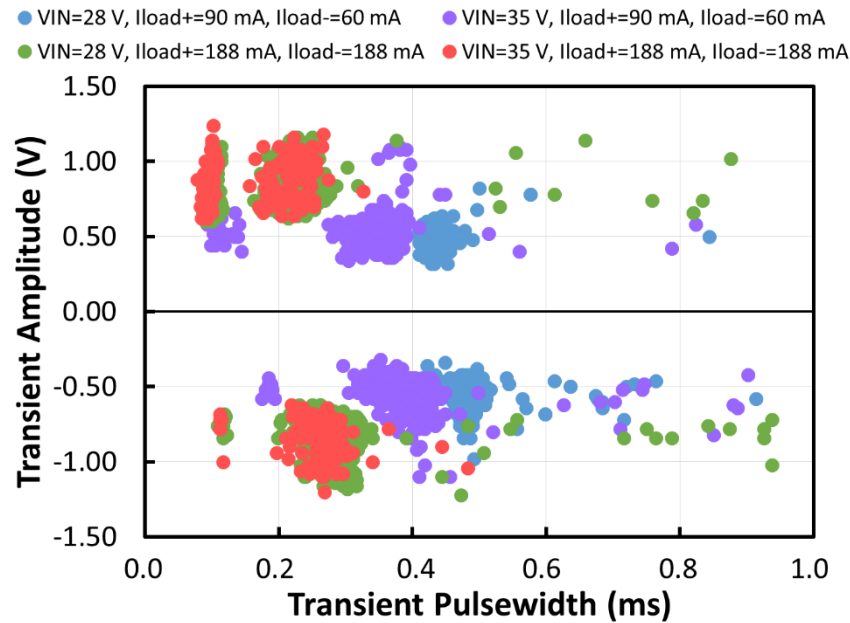
There appeared to be no difference in the two lot date codes. As mentioned above, the oscilloscope was set up to capture all transients generated with amplitude greater than 1 V above or below the output. The oscilloscope was also set to AC coupling to allow for finer resolution in the transients. When plotted, this makes the output appear to be 0 V, when it is actually 12 V. Figure 6 shows how the output appears before the beam is turned on as a reference point. There is some noise that corresponds to the 550 kHz internal constant switching frequency. Figure 7 shows the amplitudes and pulsewidths generated in the four different test conditions (two supply voltages and two load conditions). Generally, the higher load resulted in transients with greater amplitude, but shorter duration. There was no major dependence on input voltage with the larger load. The amplitudes of the transients generated with the smaller load were approximately half that of the larger load, and again, with no real dependence on the input voltage. However, the duration was consistently longer at the lower supply voltage than at the higher with the smaller load. Figures 8a-d and show the sample



transients generated for each of the test conditions. The colors of each transient also correspond to the colors in the amplitude and pulsewidth scatterplot. In all of the example transients shown, the 550 kHz internal switching noise is superimposed over the SET.



**Figure 6: 550 kHz Noise Observed on the Output of the SMHF2812D When the Beam is Shuttered**



**Figure 7: Amplitude and Pulsewidth Scatterplot for Transients Generated under the Four Different Input Voltage and Loading Conditions**

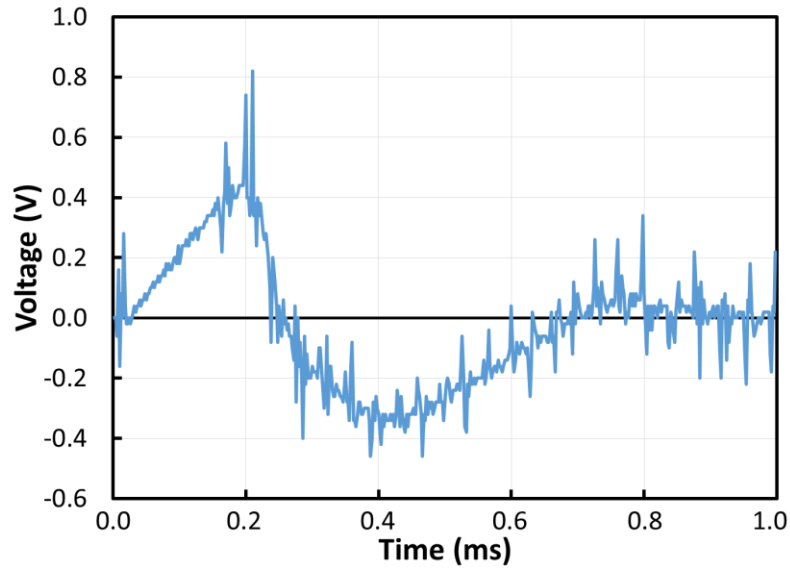


Figure 8: Example Transient Generated with  $V_{IN} = 28\text{ V}$  and  $I_{load+} = 90\text{ mA}$  and  $I_{load-} = 60\text{ mA}$

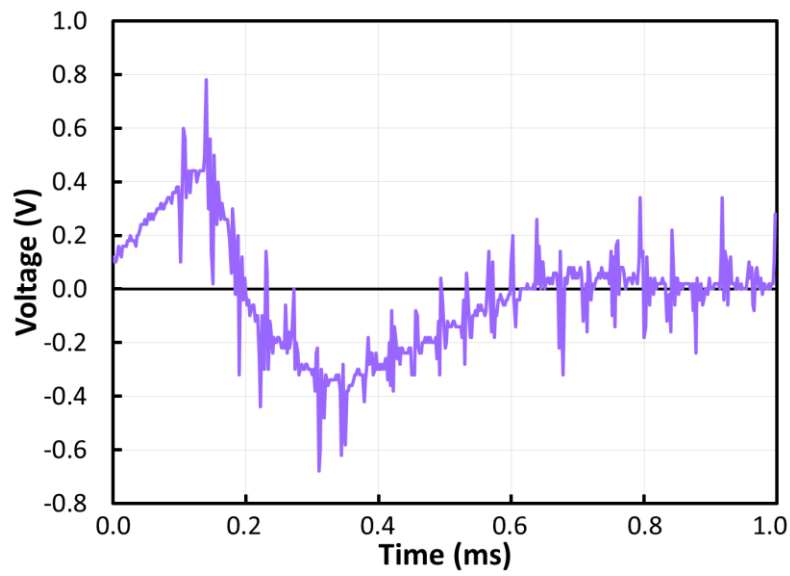
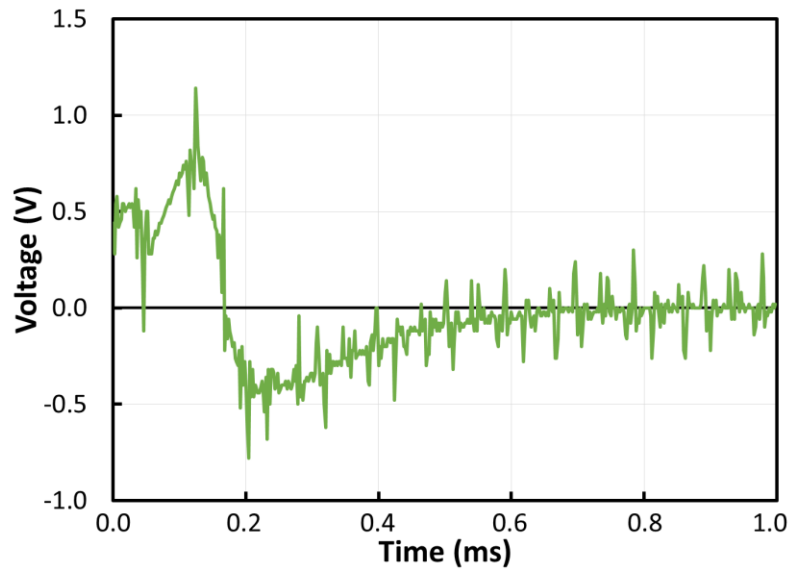
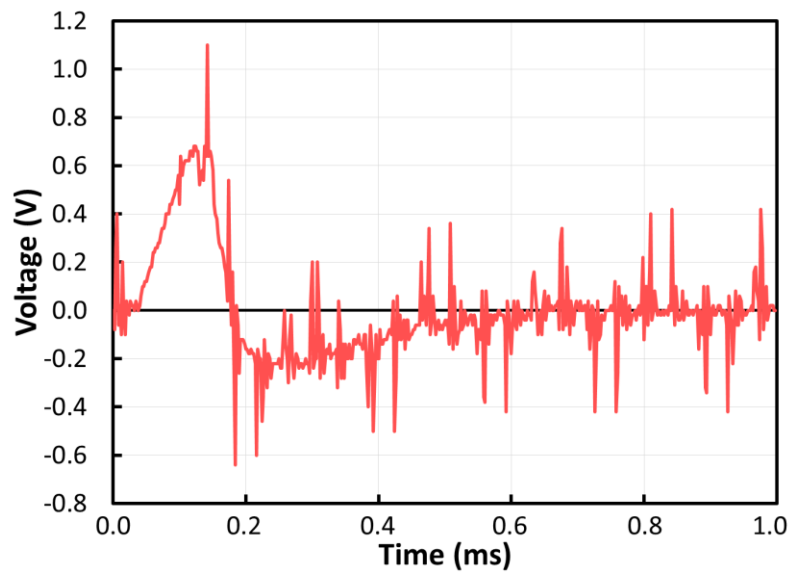


Figure 9: Example Transient Generated with  $V_{IN} = 35\text{ V}$  and  $I_{load+} = 90\text{ mA}$  and  $I_{load-} = 60\text{ mA}$





**Figure 10: Example Transient Generated with  $V_{IN} = 28\text{ V}$  and  $I_{load+} = 188\text{ mA}$  and  $I_{load-} = 188\text{ mA}$**



**Figure 11: Example Transient Generated with  $V_{IN} = 35\text{ V}$  and  $I_{load+} = 188\text{ mA}$  and  $I_{load-} = 188\text{ mA}$**

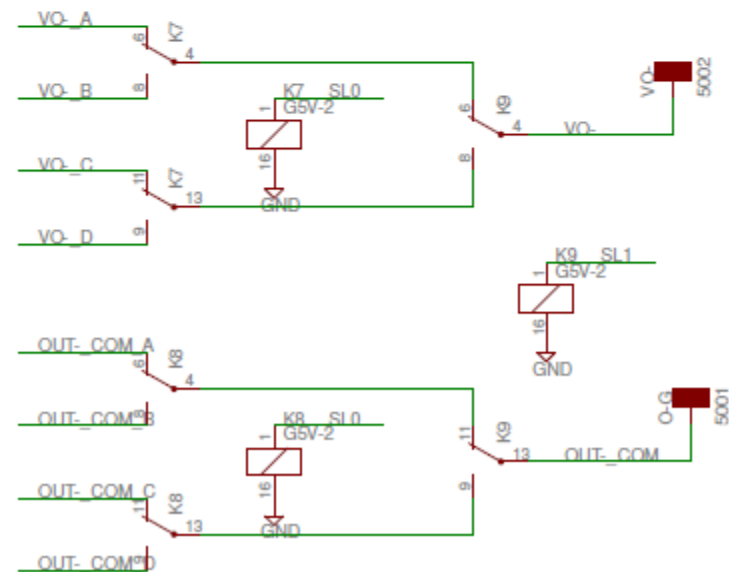
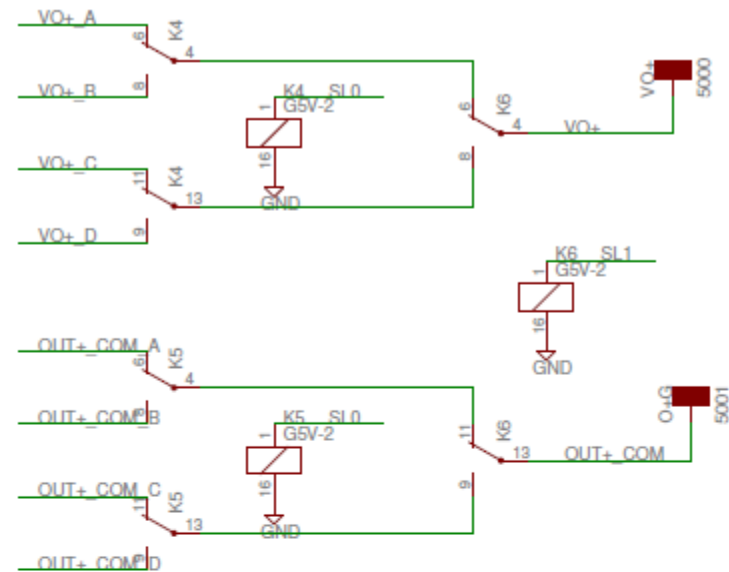
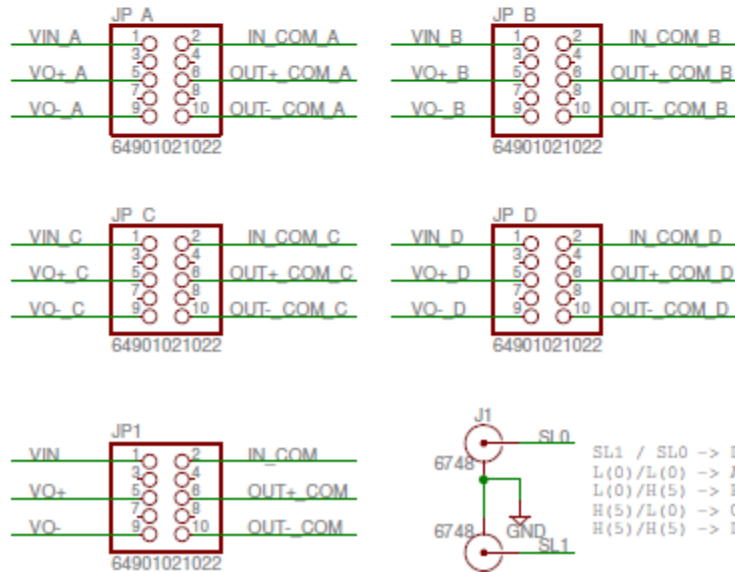
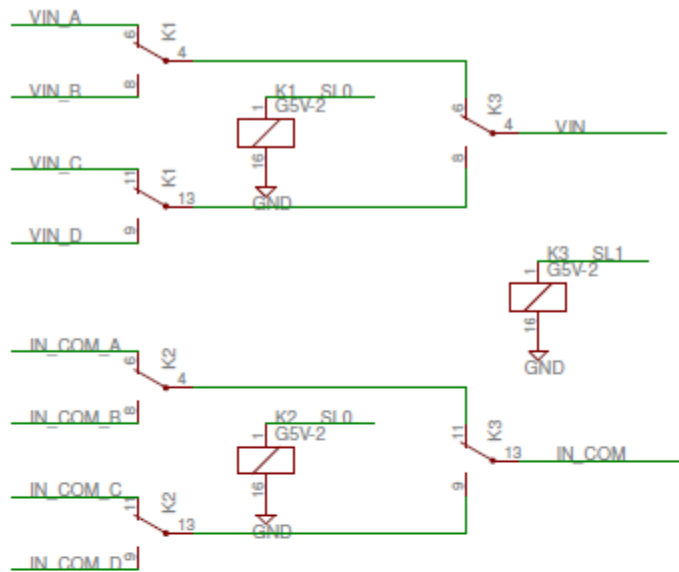
## 7. URL for Device Datasheet

SMHF Series:

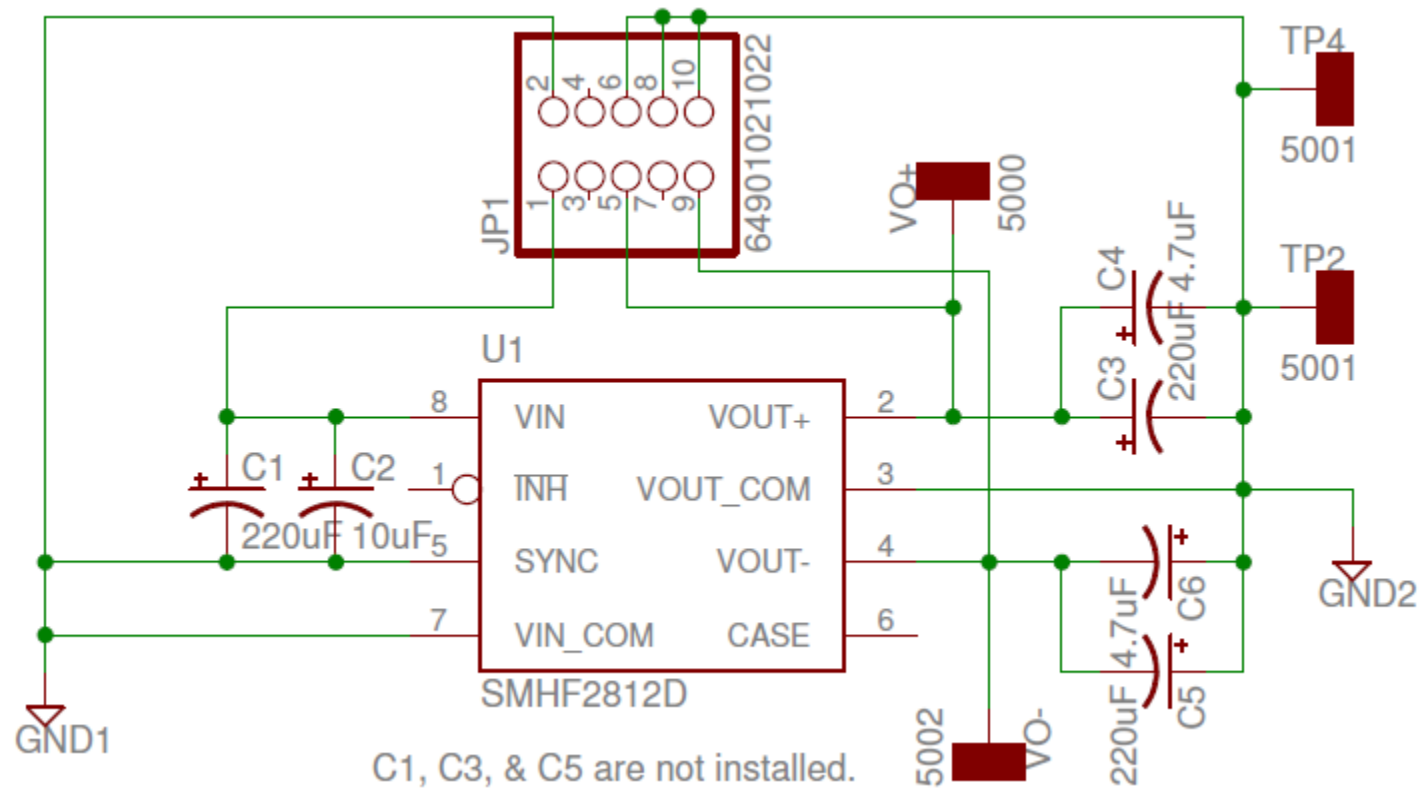
[http://www.interpoint.com/product\\_documents/SMHF\\_Space\\_DC\\_DC\\_Converters.pdf](http://www.interpoint.com/product_documents/SMHF_Space_DC_DC_Converters.pdf)



## 9. Motherboard Schematic -- for Test Purposes Only



## 10. Daughtercard Schematic -- for Test Purposes Only



## 11. Power Supply and Temperature Strip Tapes for Each Beam Run

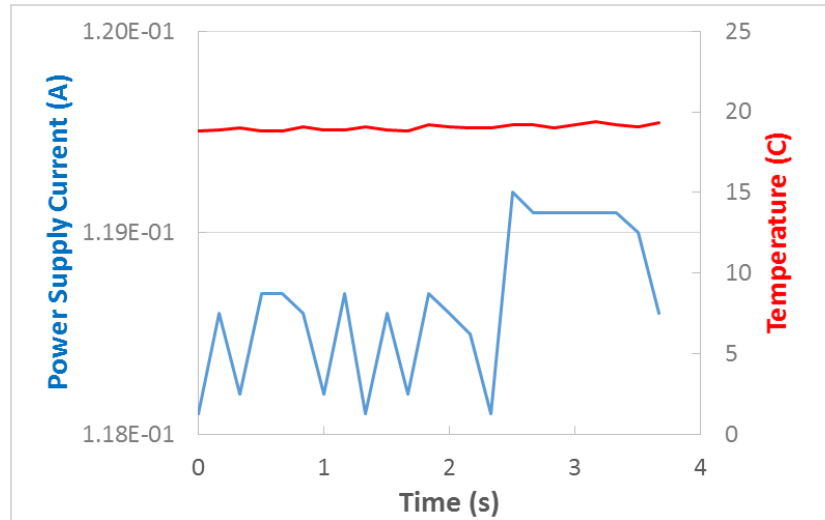


Figure 12: The Pre-Rad Power Supply Current for DUT0993 and Case Temperature While Powered

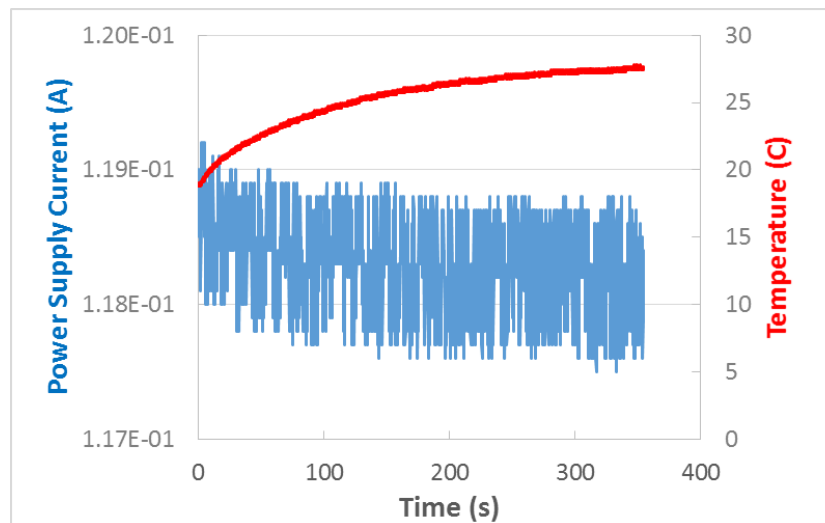


Figure 13: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 1

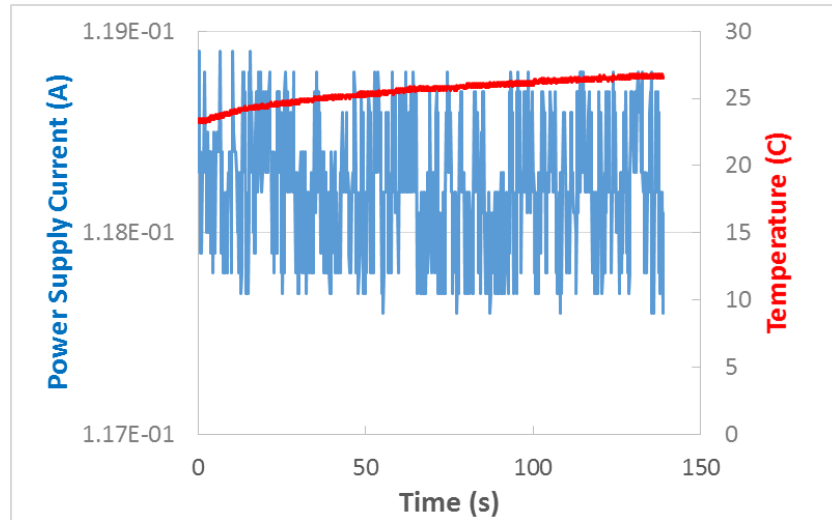


Figure 14: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 2

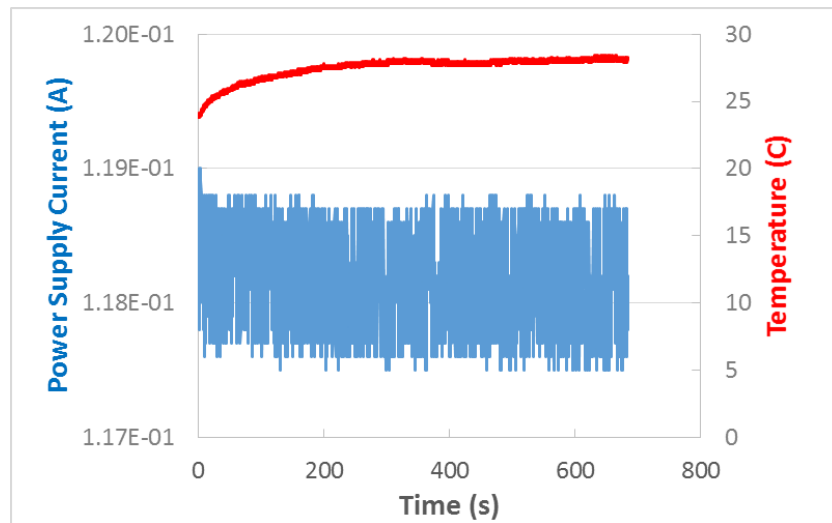


Figure 15: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 3

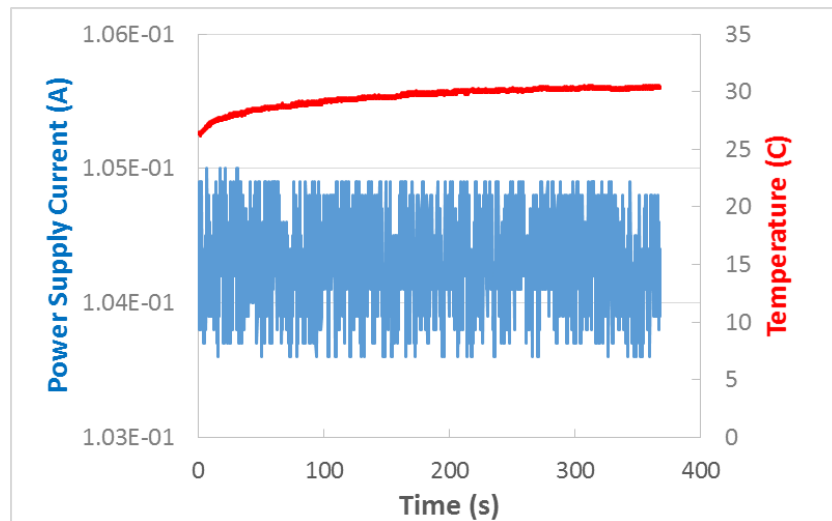


Figure 16: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 4

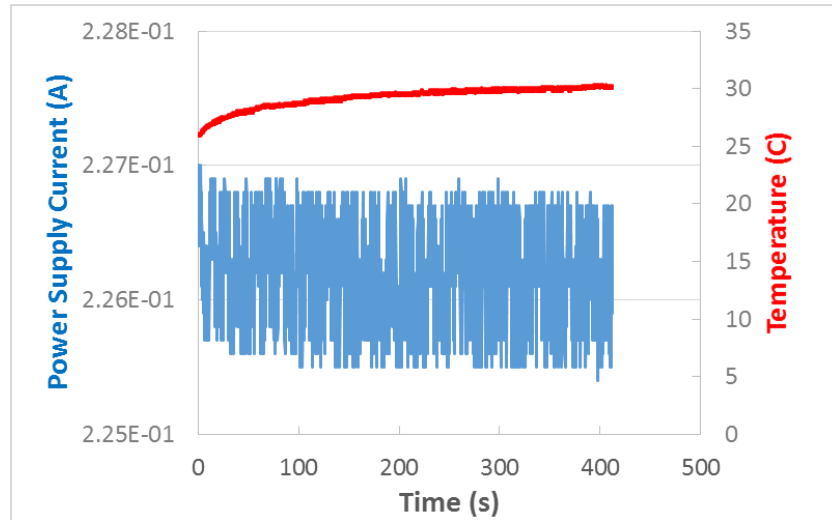


Figure 17: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 5

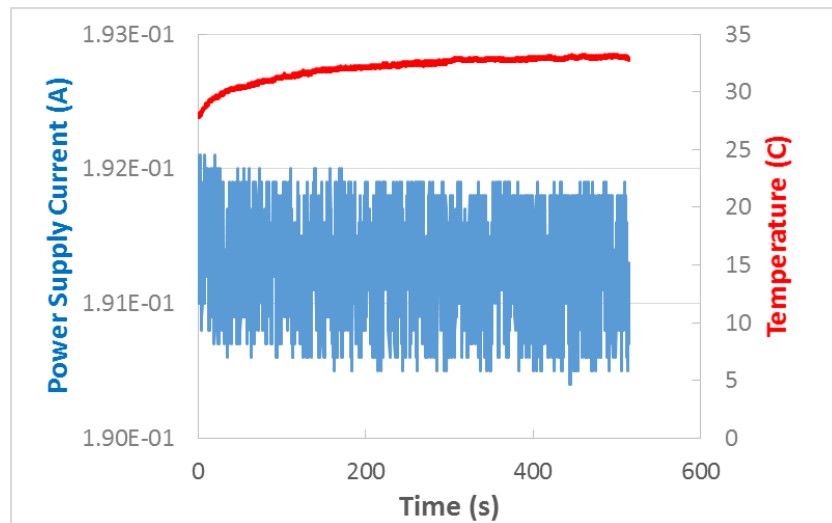


Figure 18: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 6

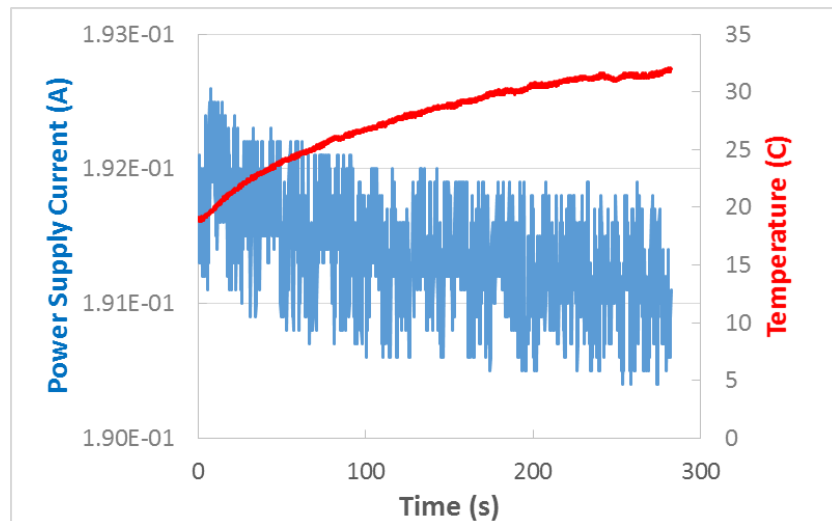
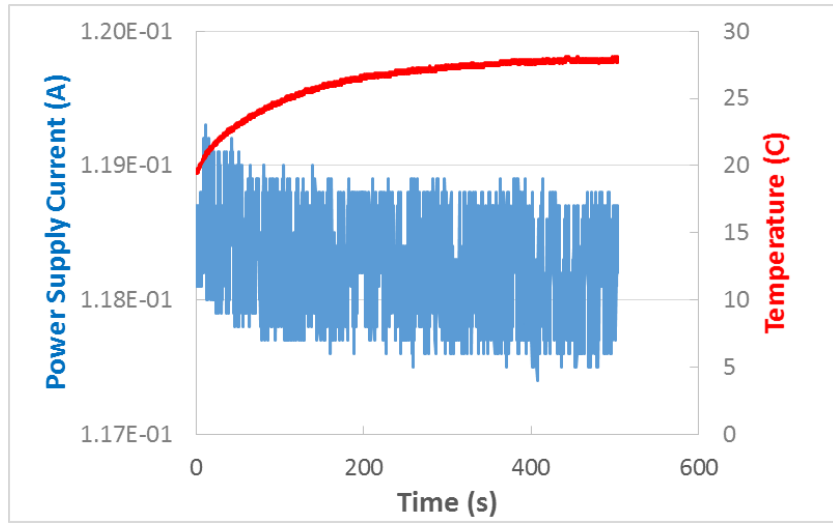
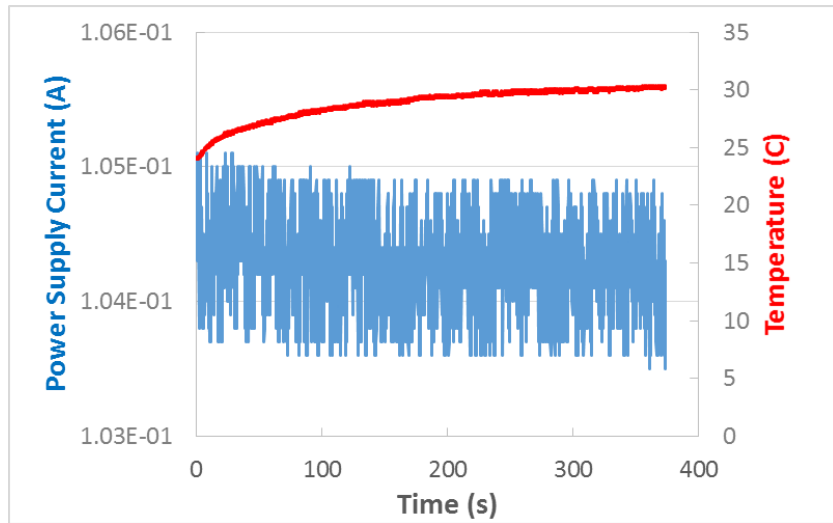


Figure 19: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 7

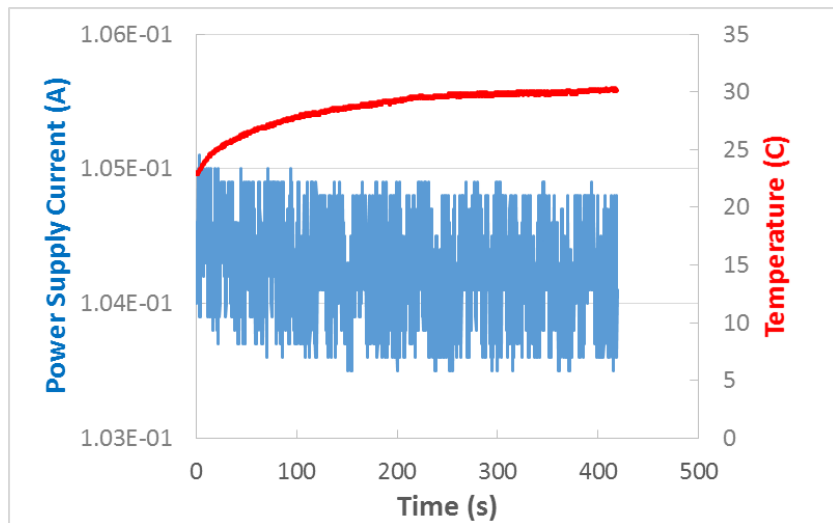




**Figure 20: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 8**



**Figure 21: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 9**



**Figure 22: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 10**

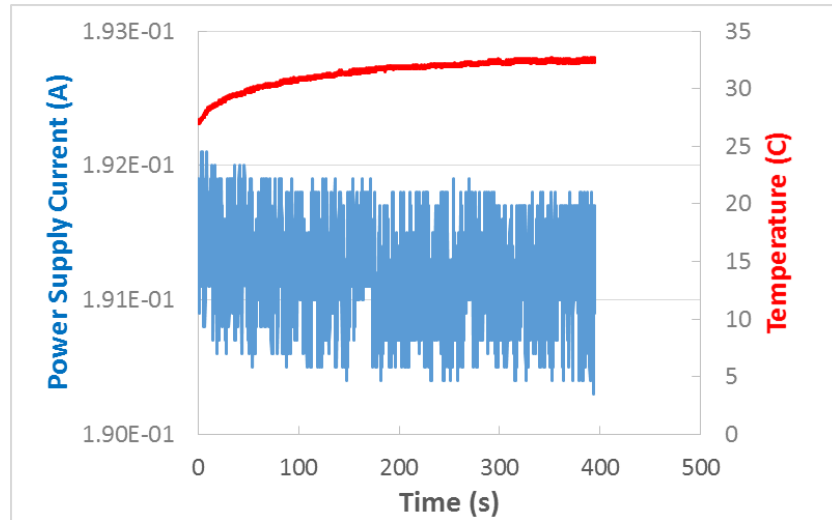


Figure 23: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 11

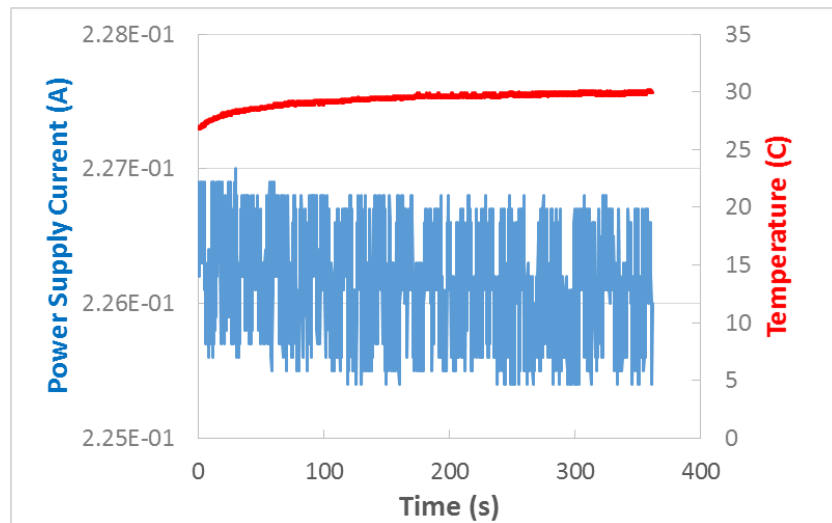


Figure 24: The Power Supply Current for DUT0993 and Case Temperature While Powered During Run 12

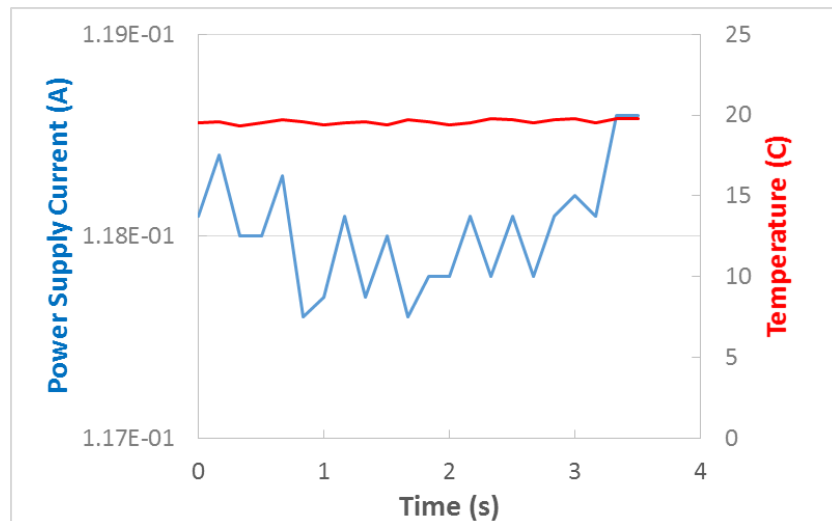
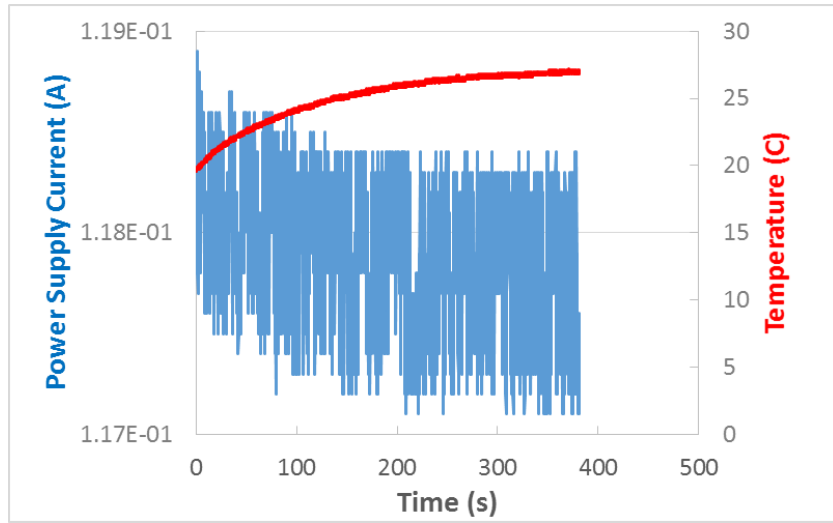
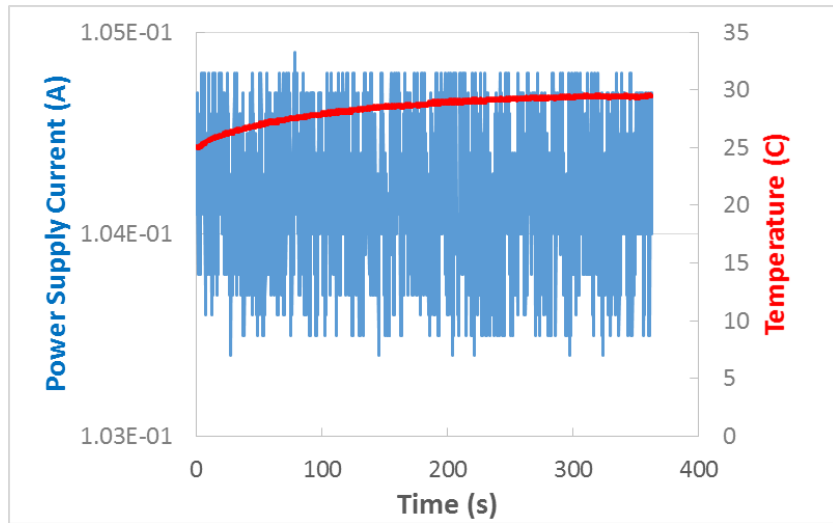


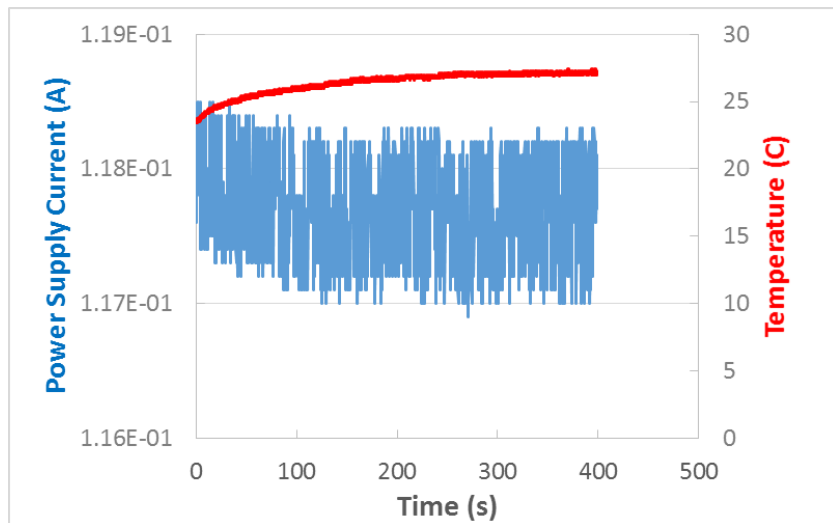
Figure 25: The Pre-Rad Power Supply Current for DUT0991 and Case Temperature While Powered



**Figure 26: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 13**



**Figure 27: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 14**



**Figure 28: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 15**

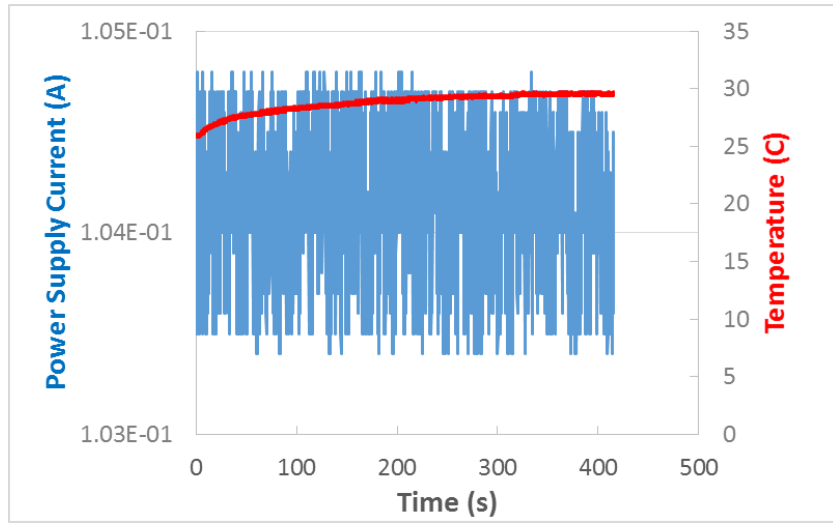


Figure 29: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 16

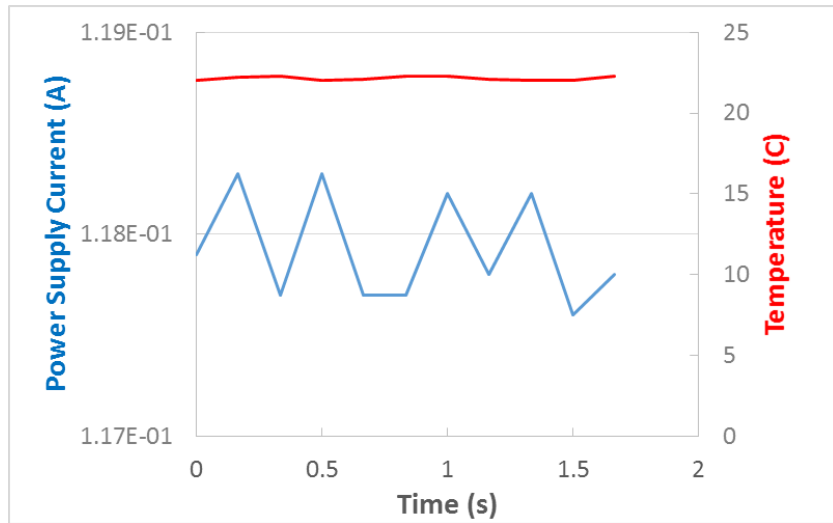


Figure 30: The Pre-Rad Power Supply Current for DUT0992 and Case Temperature While Powered

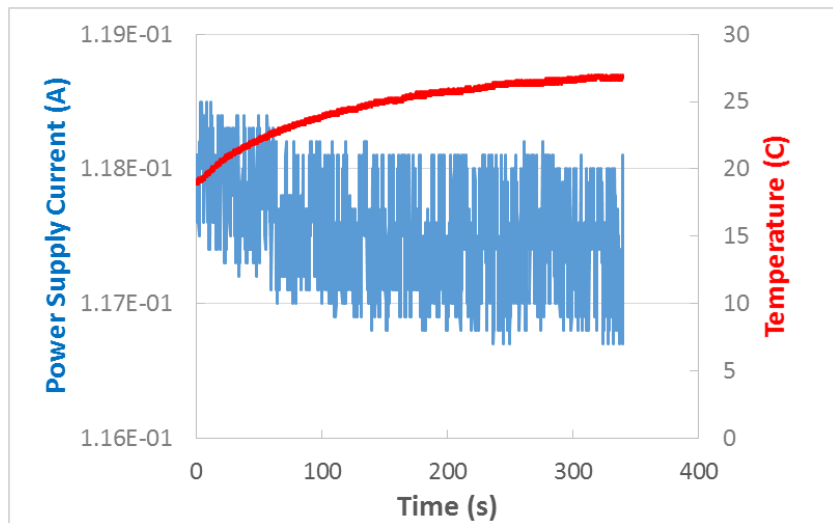
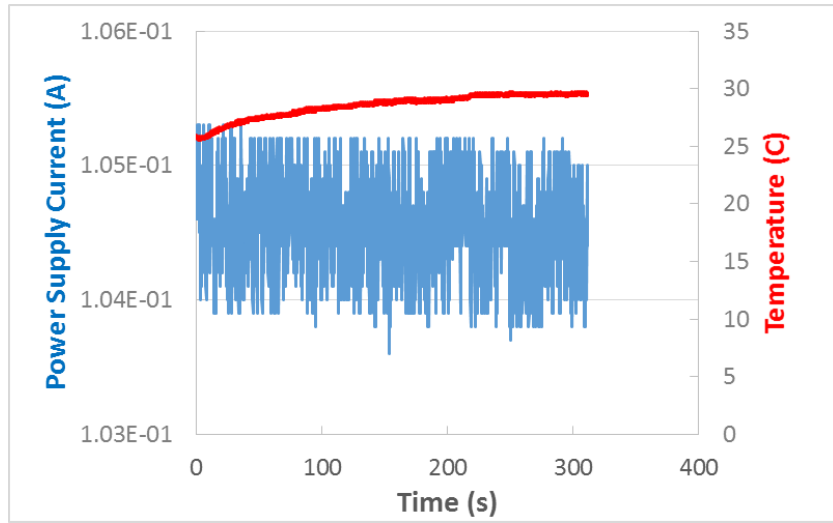
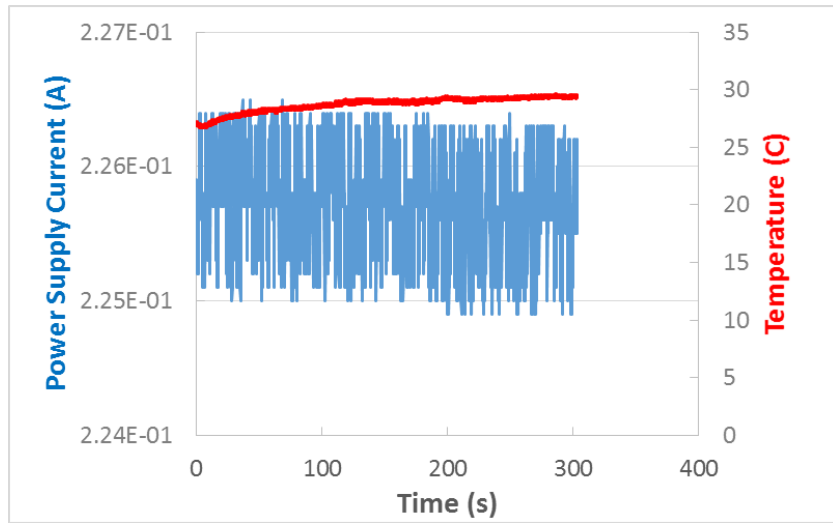


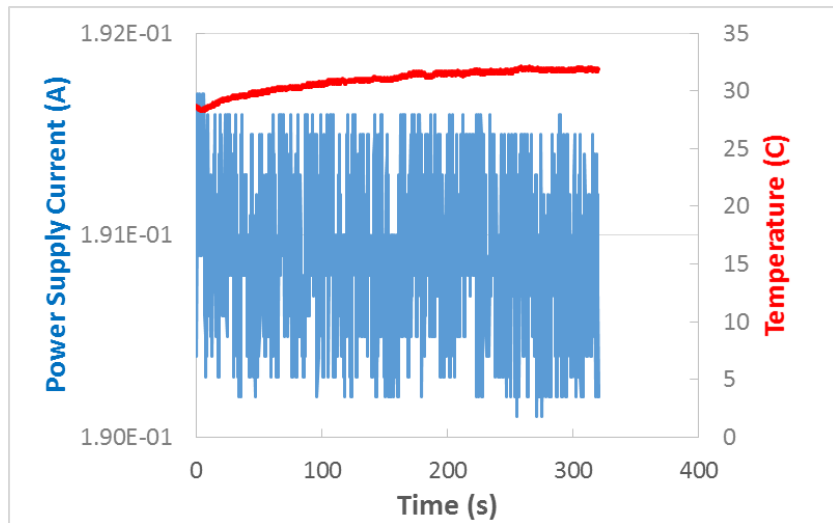
Figure 31: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 17



**Figure 32: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 18**



**Figure 33: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 19**



**Figure 34: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 20**

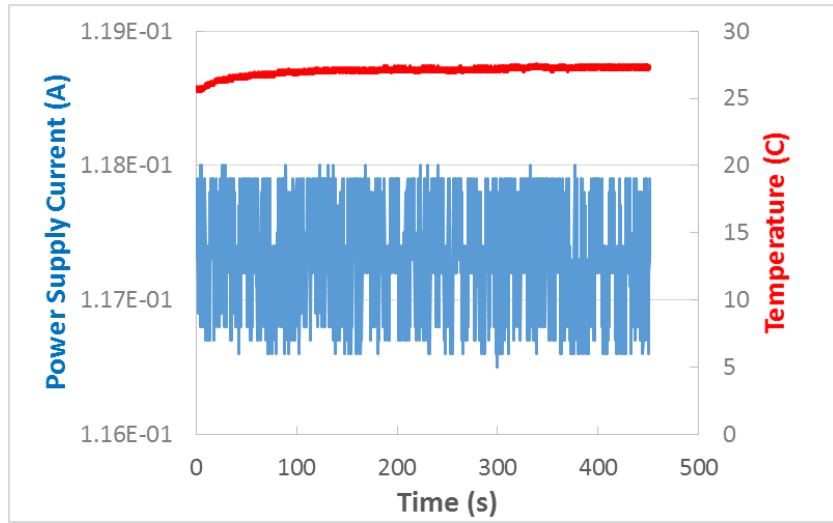


Figure 35: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 21

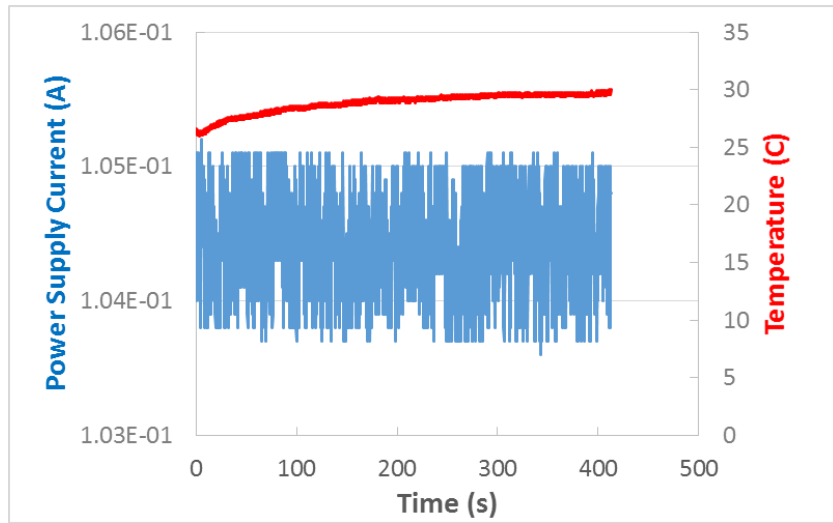


Figure 36: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 22

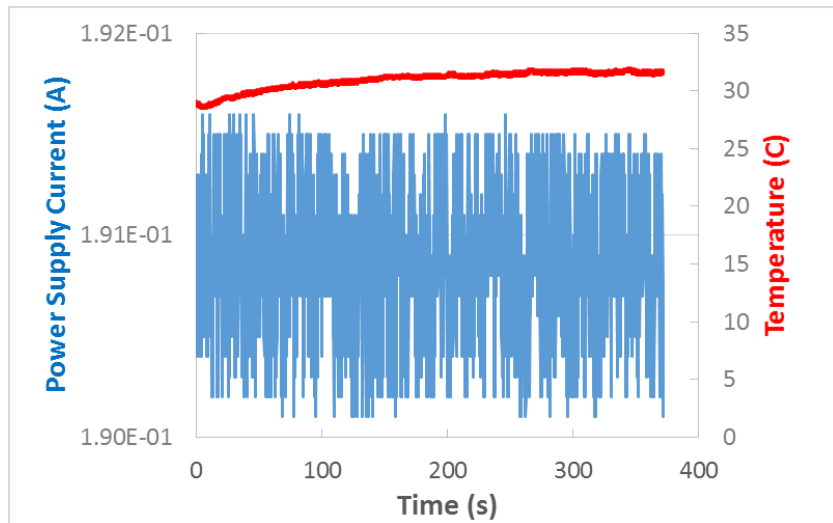


Figure 37: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 23

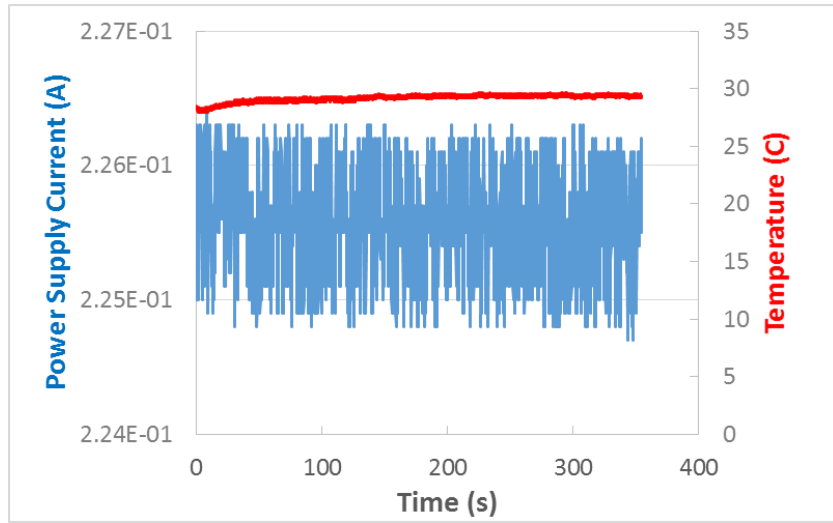


Figure 38: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 24

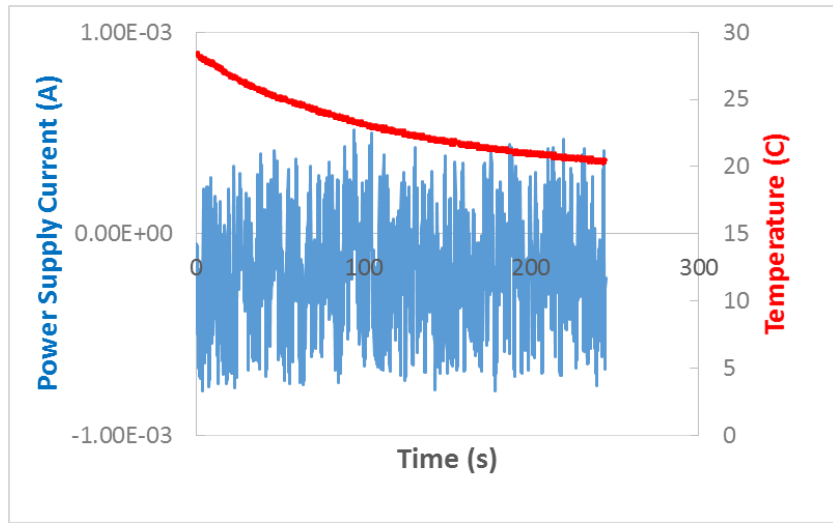


Figure 39: The Power Supply Current for DUT0992 and Case Temperature While Powered During Run 25

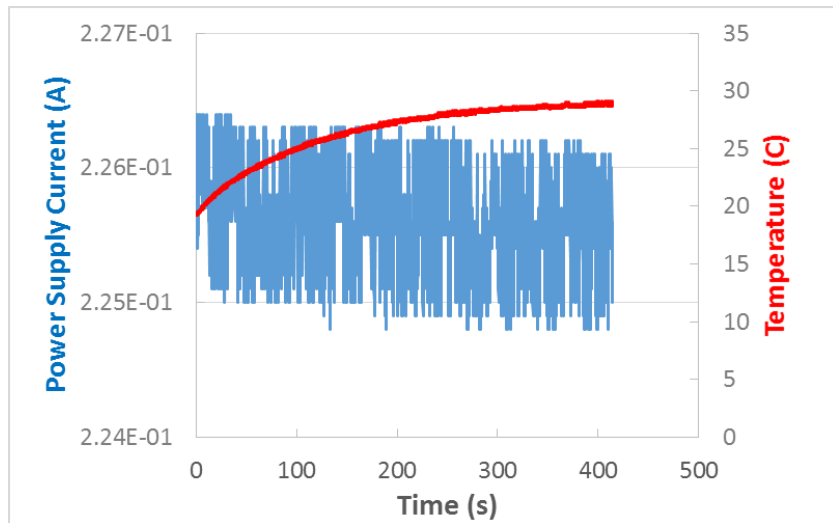
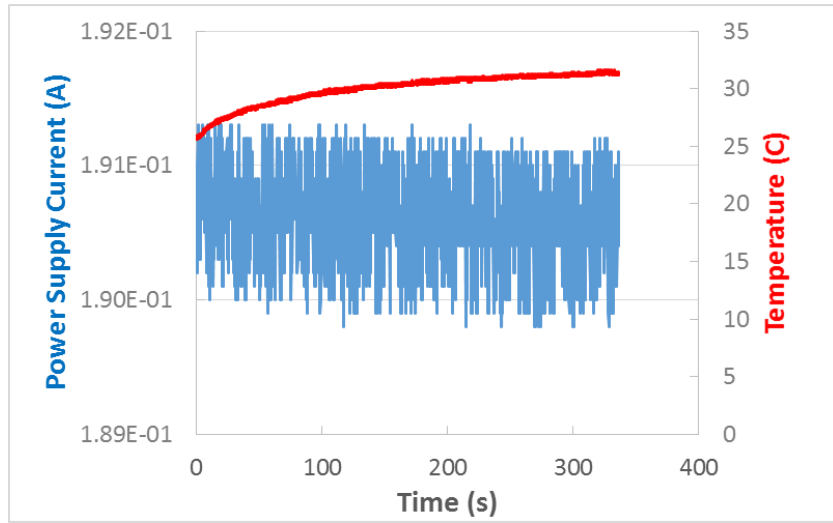
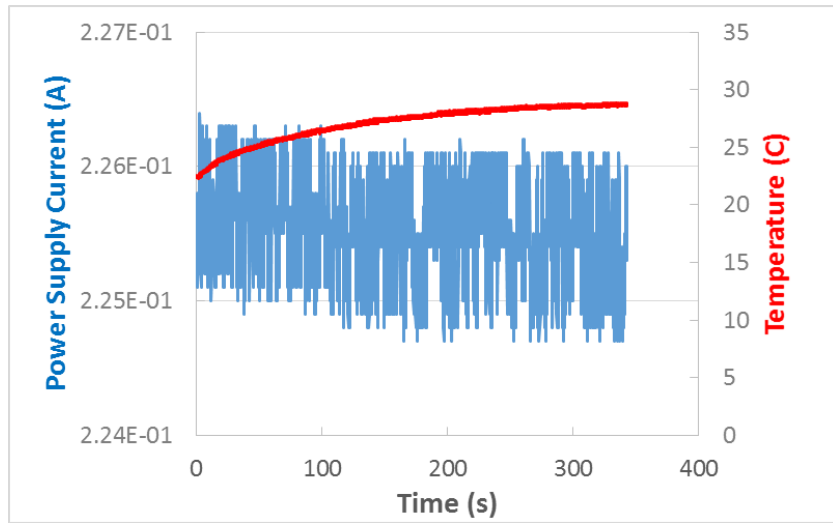


Figure 40: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 26

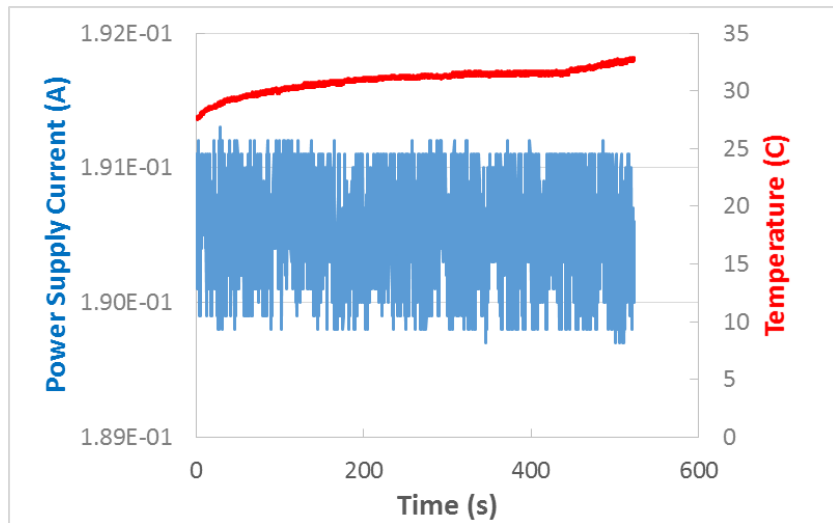




**Figure 41: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 27**



**Figure 42: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 28**



**Figure 43: The Power Supply Current for DUT0991 and Case Temperature While Powered During Run 29**

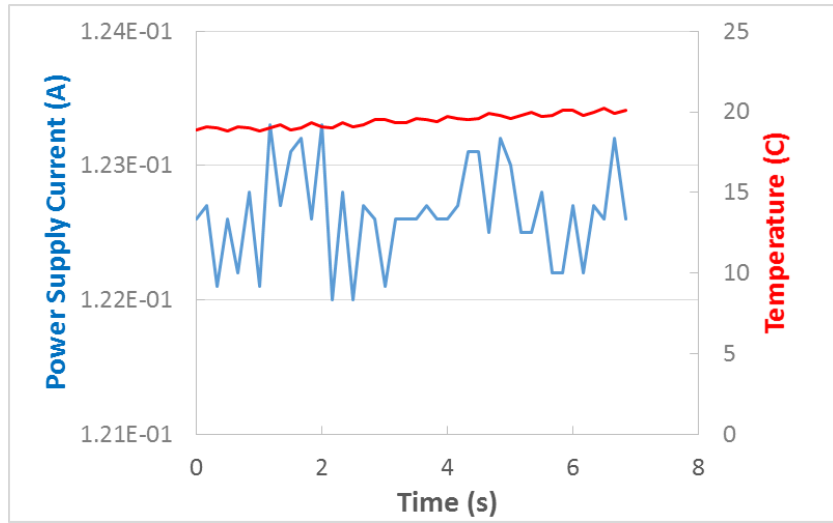


Figure 44: The Pre-Rad Power Supply Current for DUT0006 and Case Temperature While Powered

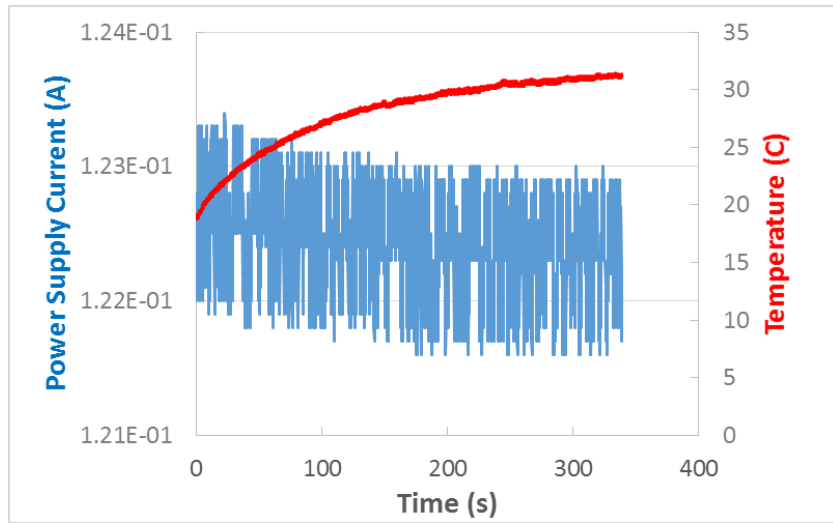


Figure 45: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 30

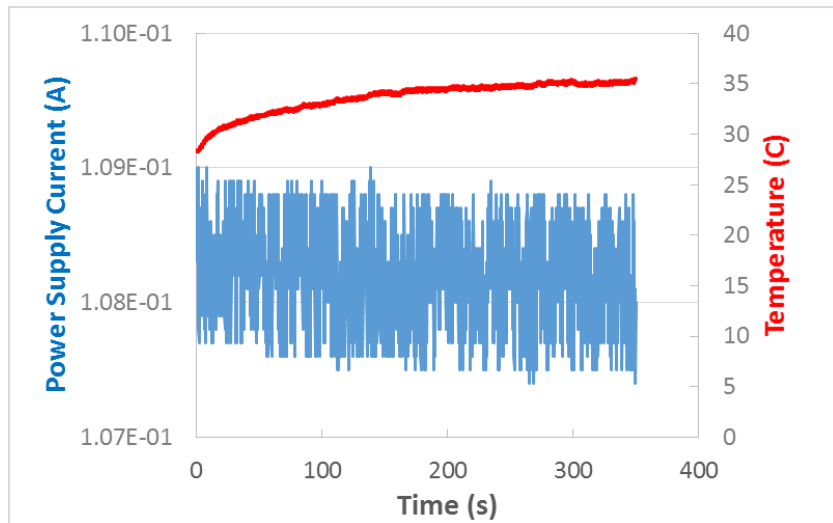


Figure 46: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 31

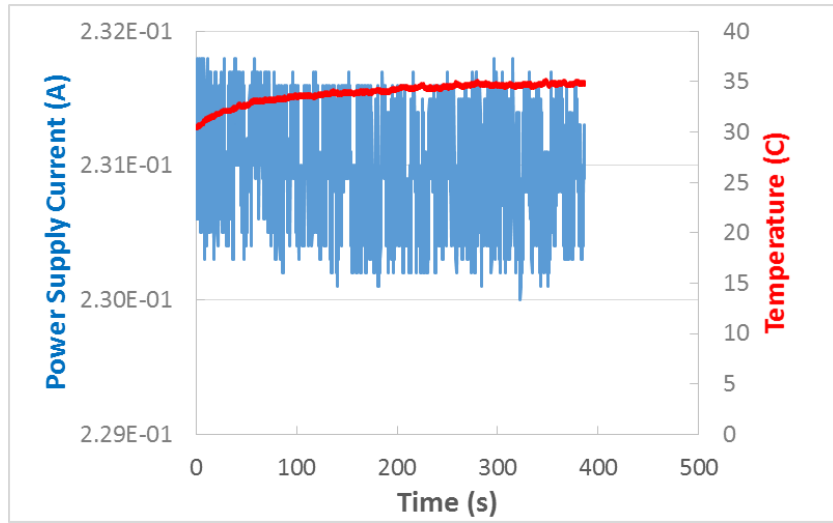


Figure 47: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 32

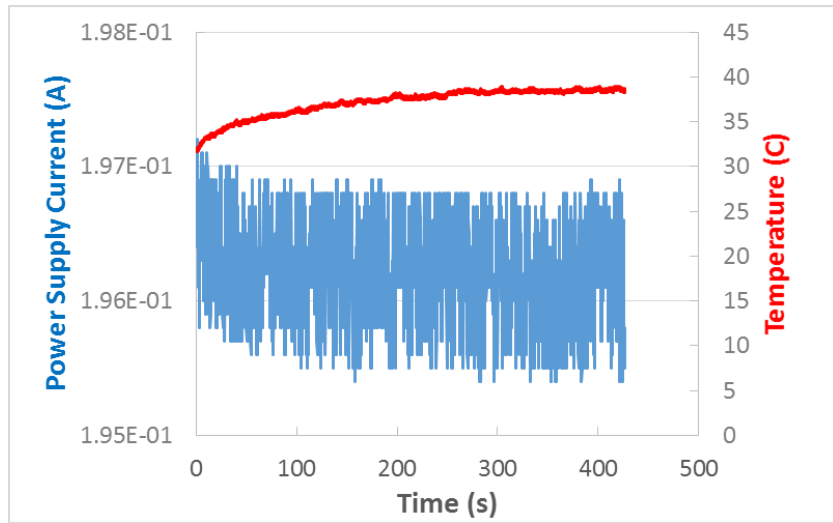


Figure 48: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 33

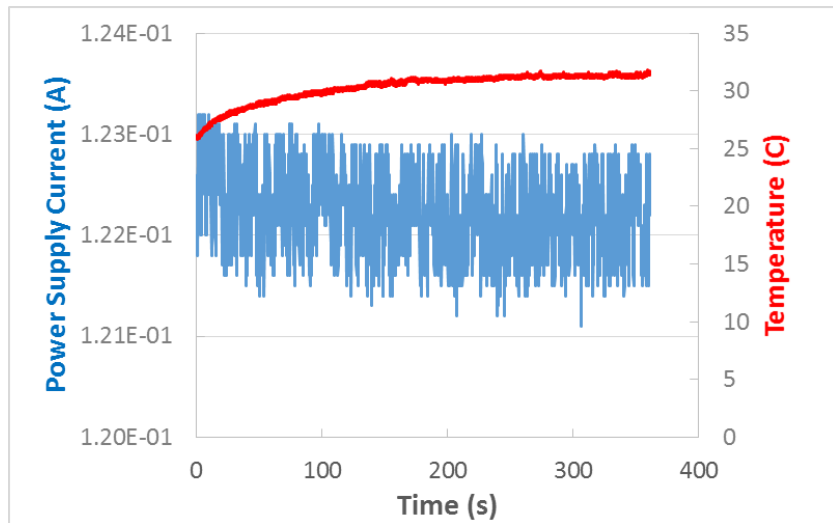
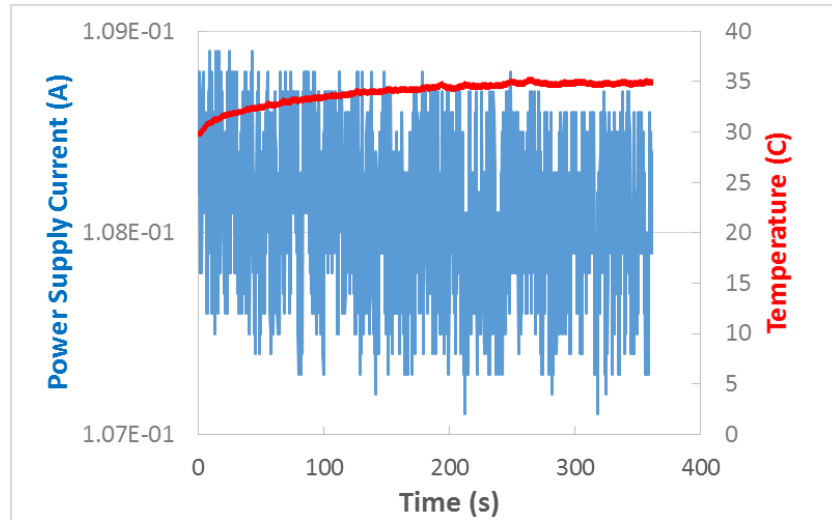
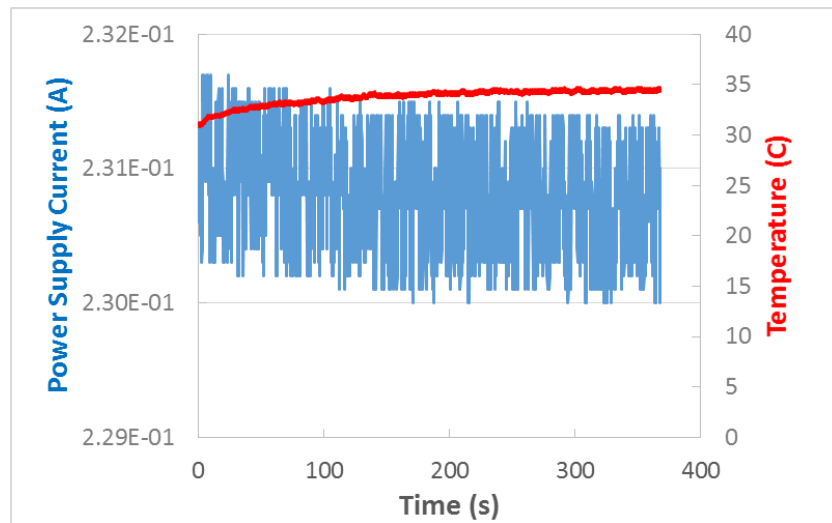


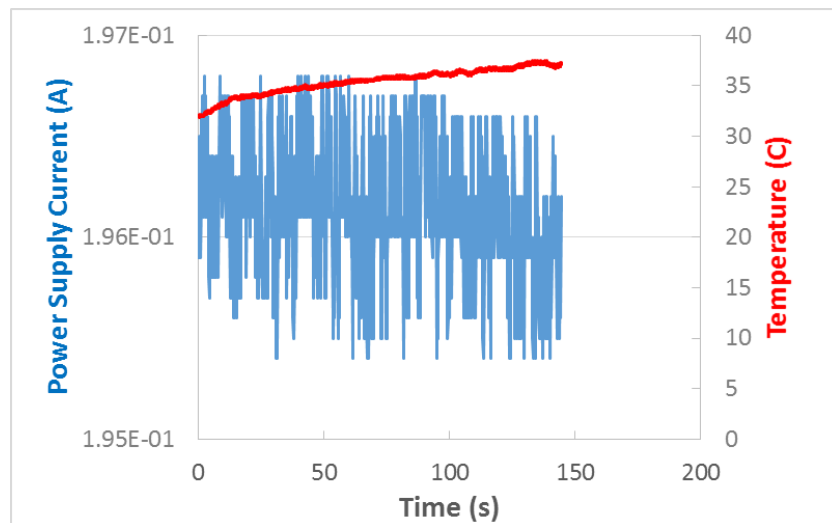
Figure 49: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 34



**Figure 50: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 35**



**Figure 51: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 36**



**Figure 52: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 37**

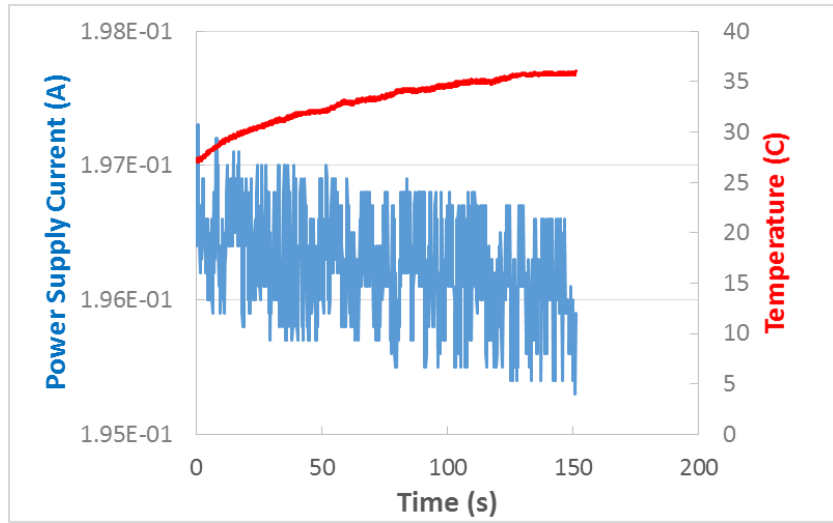


Figure 53: The Power Supply Current for DUT0006 and Case Temperature While Powered During Run 38

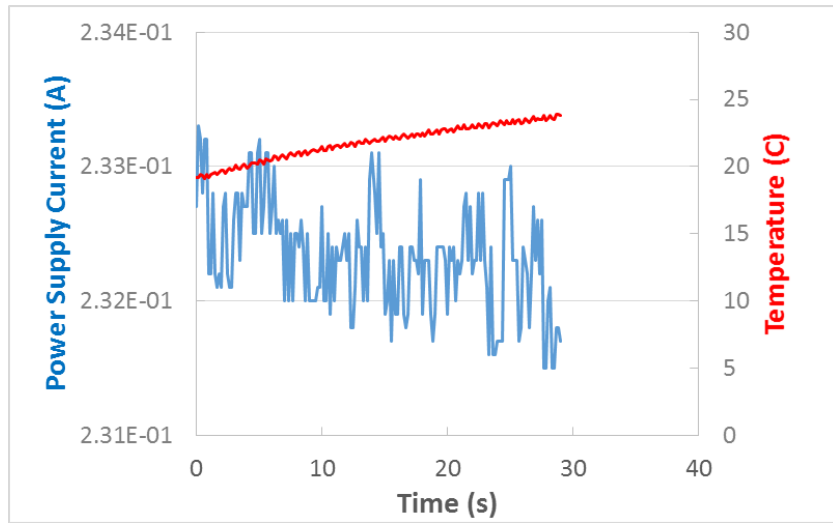


Figure 54: The Pre-Rad Power Supply Current for DUT0008 and Case Temperature While Powered

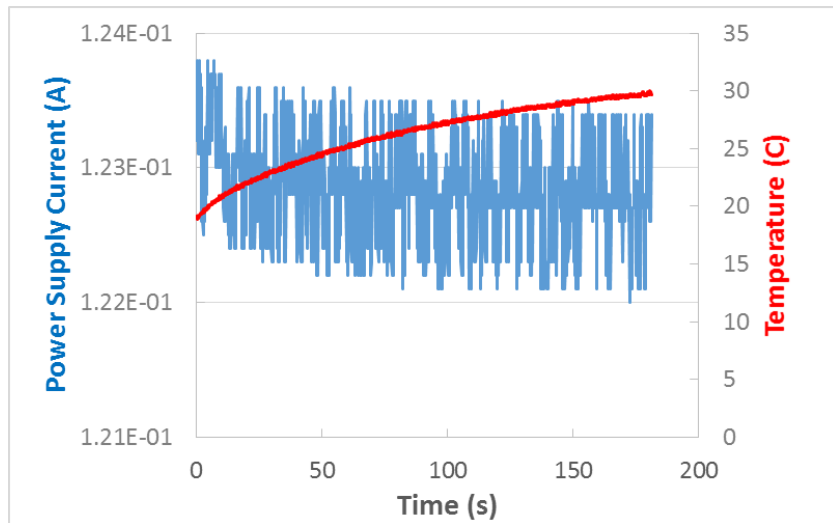


Figure 55: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 39

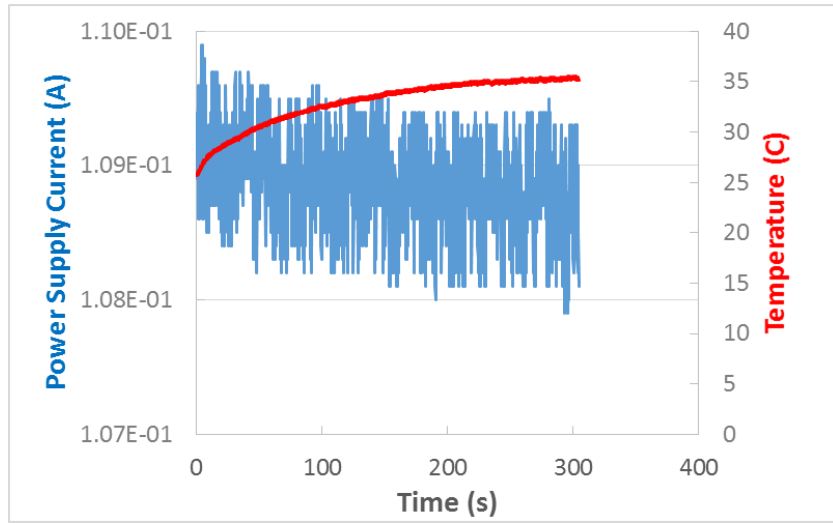


Figure 56: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 40

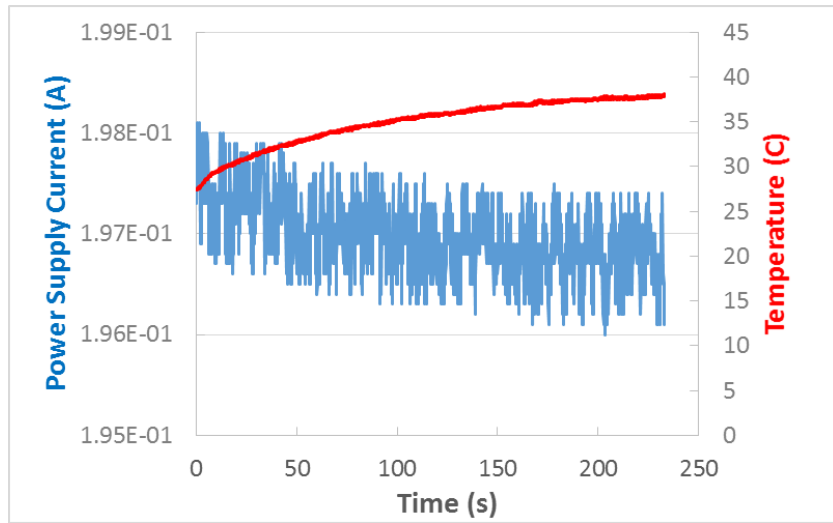


Figure 57: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 41

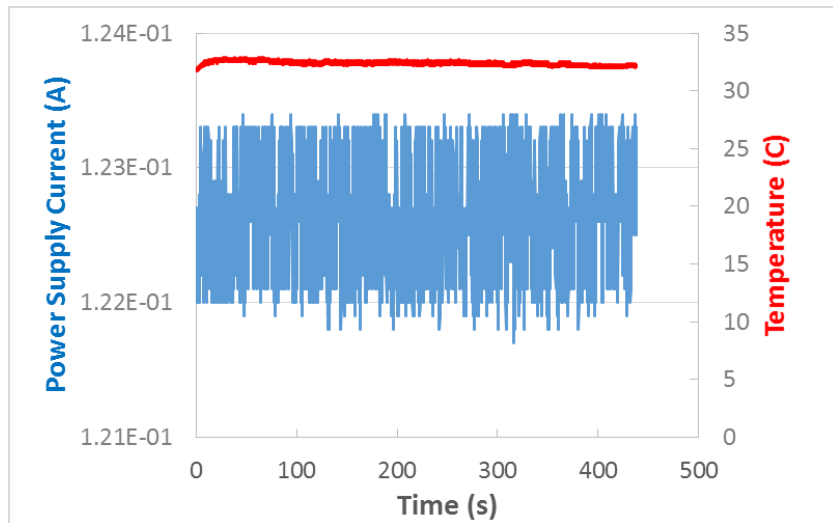


Figure 58: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 42

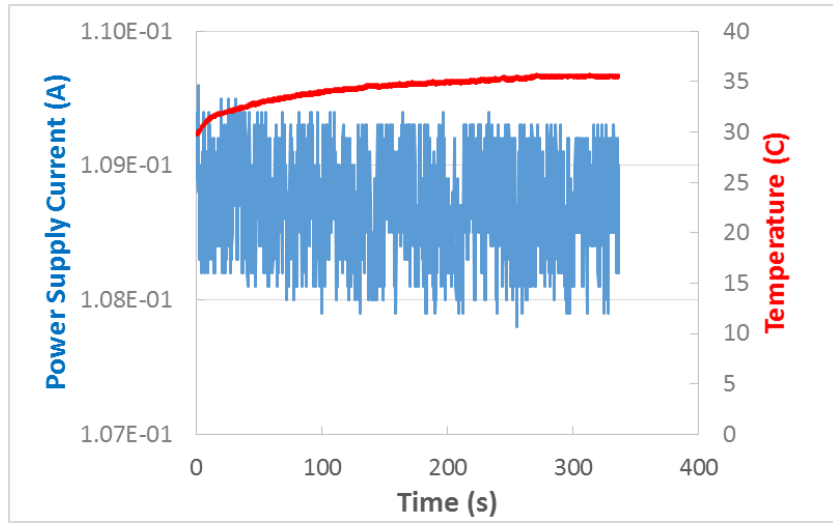


Figure 59: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 43

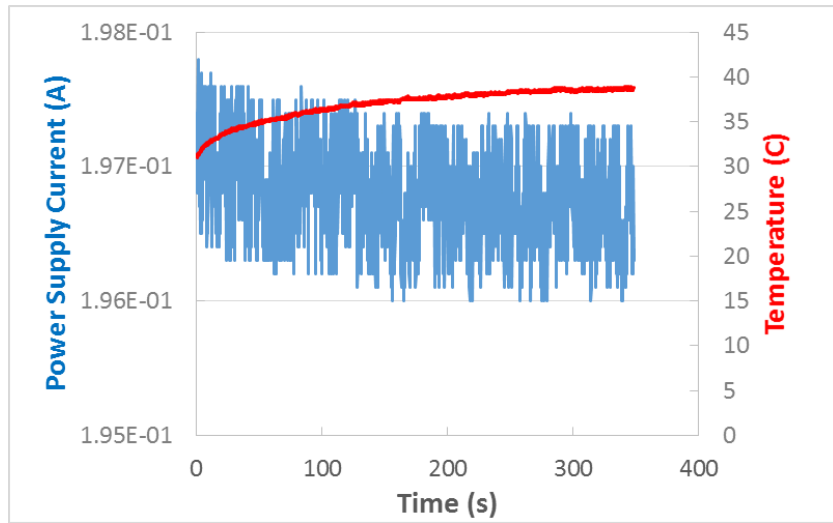


Figure 60: The Power Supply Current for DUT0008 and Case Temperature While Powered During Run 44

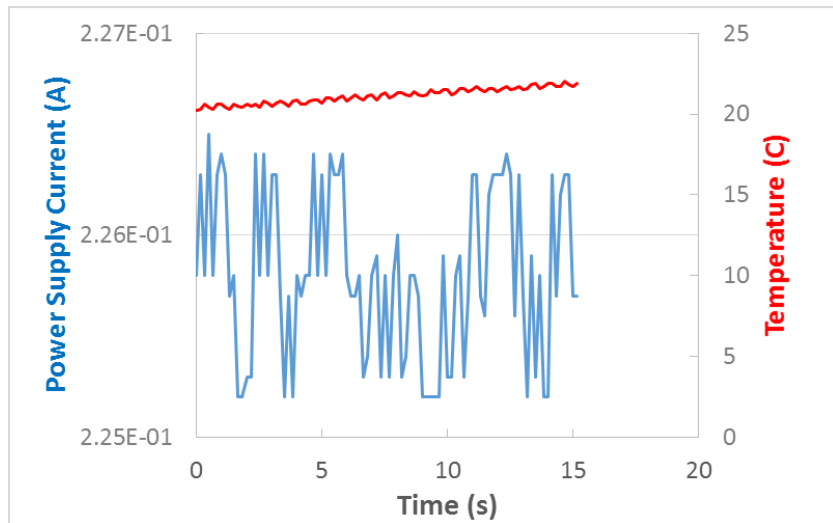


Figure 61: The Pre-Rad Power Supply Current for DUT0994 and Case Temperature While Powered



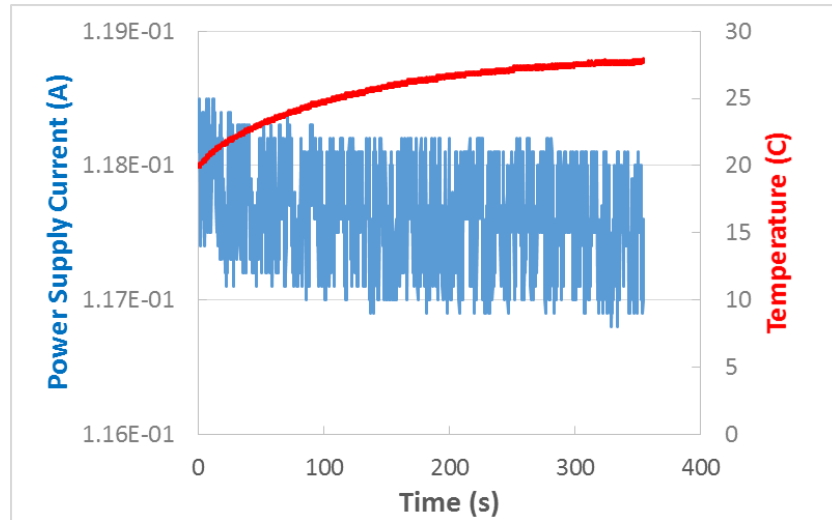


Figure 62: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 45

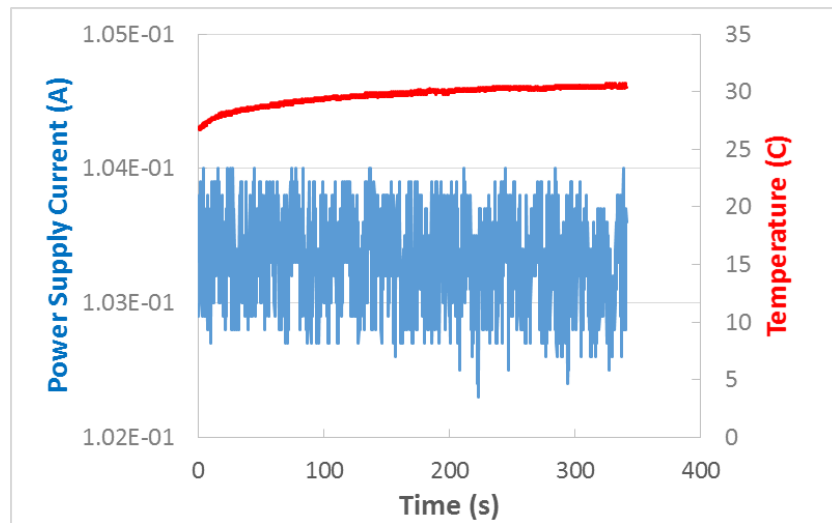


Figure 63: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 46

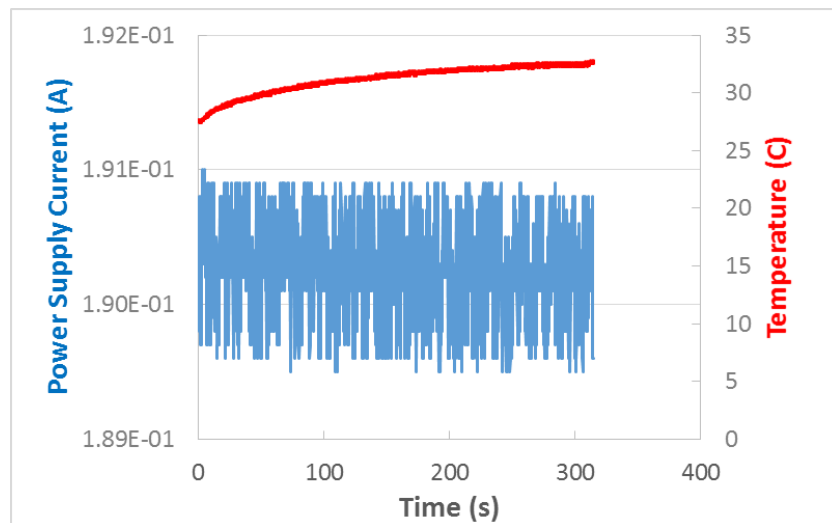


Figure 64: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 47

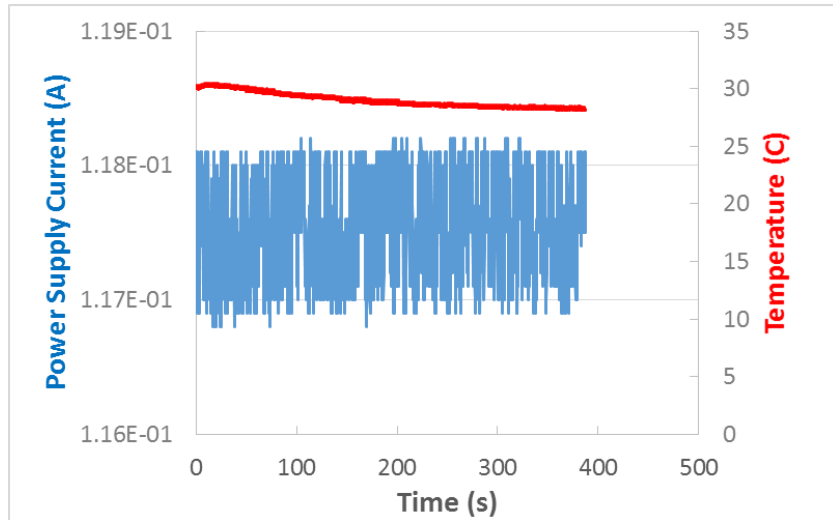


Figure 65: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 48

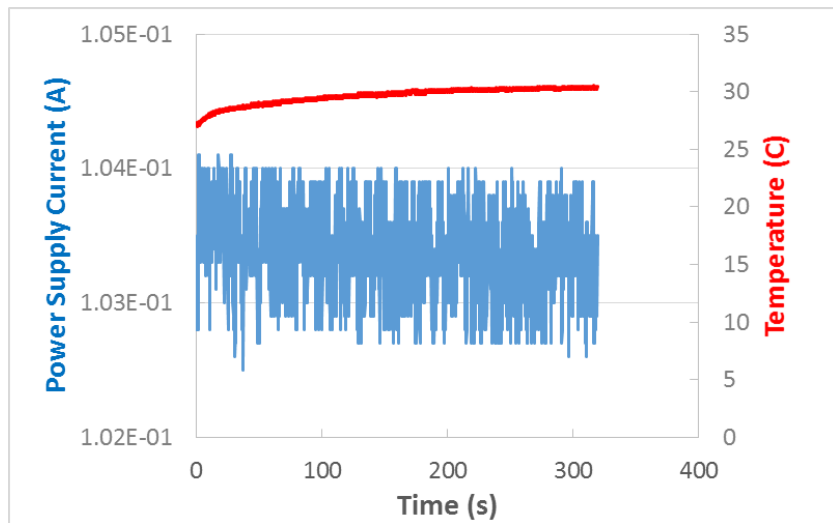


Figure 66: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 49

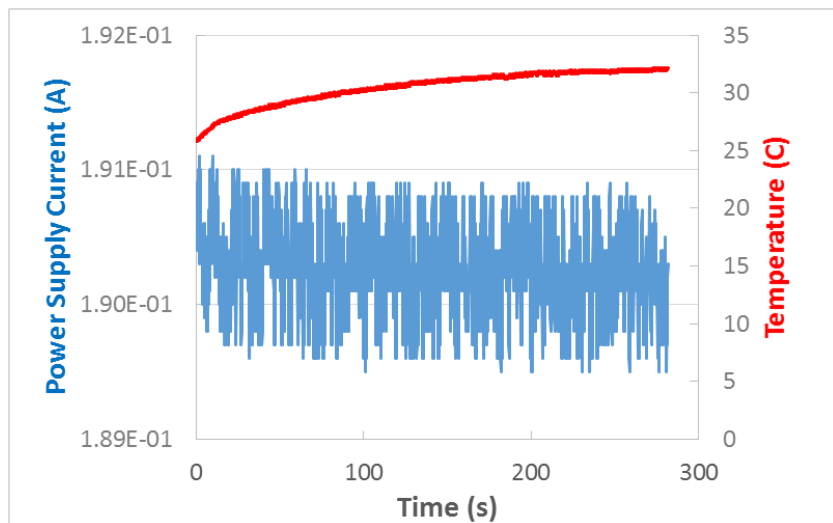


Figure 67: The Power Supply Current for DUT0994 and Case Temperature While Powered During Run 50